

BOYS TOWN NATIONAL RESEARCH HOSPITAL

PUTT User Manual

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ABSTRACT

PUTT is a program for measuring and displaying hearing thresholds. The name PUTT is derived from "pure-tone thresholds." It was designed to investigate whether sound intensity level (SIL) could eliminate the problem of standing waves when sound levels are measured in the ear canal. Recent versions include forward pressure level (FPL) as alternative way to quantify sound level. PUTT implements both maximum likelihood and staircase tracking methods to determine threshold. Tones are presented in a single interval, yes/no paradigm, or in a two-interval forced choice paradigm. Parameters of the stimulus presentation and threshold determination are specified in a configuration file. PUTT will work with most high-quality soundcards (e.g., CardDeluxe, Gina3G, Indigo io) and uses synchronous averaging for stimulus calibration.

This document describes PUTT version 2.29.

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1. Introduction

PUTT is a contraction of “pure-tone thresholds.” A special feature of the program is its ability to quantify sound levels in terms of sound intensity level (SIL) or forward pressure level (FPL) as alternatives to the sound pressure level (SPL) directly measured by a microphone in the ear canal. These alternate calibration methods require that a microphone be attached to the sound source (i.e., receiver or loudspeaker) that is placed in the ear canal. The combination microphone/loudspeaker can be a probe designed for measurement of otoacoustic emissions (e.g., ER-10C or ER-10B+ from Etymotic Research) or a custom-fitted hearing-aid ear-mold with the tube of a probe microphone (e.g., ER-7C) taped to its side.

PUTT runs on Windows and Linux systems. See Appendix A for information about program installation.

No soundcard is required to use PUTT for displaying data files; however, sound-source calibration requires a soundcard that is capable of synchronous averaging. PUTT should work with most high-quality soundcards (e.g., CardDeluxe, Gina3G, Indigo io). See Appendix B for information about soundcard installation.

SIL and FPL calibration require determination of Thévenin-equivalent source parameters (i.e., source pressure and source impedance) be determined for the sound source. The Thévenin-equivalent source parameters calculated from measurements in a set of standard acoustic cavities. PUTT provides a “Probe” test for making the necessary cavity measurements. Appendix C describes the construction of a set of calibration cavities used at BTNRH.

PUTT implements both maximum likelihood and staircase tracking methods to determine threshold. Tones are presented in a single interval, yes/no paradigm, or in a two-interval forced choice paradigm. Parameters of the stimulus presentation and threshold determination are specified in a configuration file.

2. Tutorial

Several steps are required prior to the first time that the PUTT program is used. (1) Program installation is described in Appendix A. (2) Soundcard installation is described in Appendix B. (3) Use the `arsc_chk` program to determine input/output volts-full-scale for soundcard. (4) Attach the microphone/loudspeaker hardware to the soundcard. (5) Use the “Tone” test PUTT to measure volts/pascal values for the loudspeaker and microphone. (6) Edit a copy of `putt.ini` in the working directory to specify local values for the PUTT program parameters.

Prior to administering a hearing test, determine the Thévenin-equivalent source parameters using PUTT’s “Probe” test. This requires placing the microphone/loudspeaker “probe” in each of the calibration cavities and making a pressure response measurement. The set of pressure responses for each cavity are combined and stored in a single CAL file. When the measurement in each of the cavities is satisfactory, PUTT will calculate the Thévenin-equivalent source parameters and store them in a THS file that has the same name as the CAL file. The valid THS file is required before initiating a hearing test.

The first step in the hearing test is to record a pressure response in the listeners ear canal. This pressure response is stored in a CAL file that has a letter ‘H’ as the sixth character. The information in this CAL file is combined with the information in the selected THS file to determine Thévenin load parameters (load pressure and load impedance), which are stored in THL file that has the same name as the CAL file.

When the ear-canal measurement is satisfactory, the user selects at which set of frequencies should be tested. For a yes/no task, the listener responds by pressing ‘y’ or Space on the keyboard or pressing the “left” button of the mouse when the tone is heard. PUTT assume the listener did not hear the tone when there is no response within 1 second after the end of the tone. For a two-interval task, the listener responds by ‘1’ for the first interval or ‘2’ for the

second interval. The threshold sound levels for selected set of frequencies is stored in a TTH file that has the same name as CAL file that contains the ear canal pressure response.

The File/Open function can be used to view either CAL or TTH files.

3. Configuration parameters

The configuration (initialization) file is called “putt.ini” by default and can be located either in (1) the current directory, (2) the directory containing the program (putt.exe), or (3) any directory listed in the PATH environment variable. The configuration file is divided into five sections SYSTEM, PRINTER, HEARING, PROBE, and TONE. Each section begins with a line containing the name of the section enclosed in brackets. The parameters that can be given values are described below for each section. The default value for each parameter is indicated. Lines that begin with a semicolon in the configuration file are ignored and can be used for comments or to temporarily disable a parameter setting. The letters in the parameter name are not case-sensitive. Many of the parameters may also be set through the Options menu in PUTT. Changing a parameter value within PUTT will not change the default value specified in the configuration file.

SYSTEM Parameters

The SYSTEM section begins with a line containing the word SYSTEM in brackets like this: [SYSTEM]. Parameters in this section apply to all tests. They are specific to the sound card and the load characteristics of your hardware, therefore separate configuration files may need to be required for different equipment configurations. The following list of SYSTEM parameters includes default values.

AD_type = 0

This parameter is obsolete. Previously, if this parameter were set to 1, the program would skip clock synchronization checks for the Ariel DSP-16+.

DSP = W

Type of soundcard: W=Windows.

DSP_code =

Name of the file containing DSP code that needs to be uploaded to the soundcard.

GREG = 16

This parameter is obsolete. Previously, this parameter modified the allocation of data memory. The current version always allocates 16K words of for data, which allows DPOAE size up to 2048, and TEOAE size up to 1024.

refresh = 5

Number of seconds between automatic screen refreshes. If refresh is set to zero, automatic refresh is disabled.

The following parameters modify the Hearing Test in PUTT when specified in putt.ini. Program default values are in brackets.

DA1_sensitivity = 0

Sensitivity of the first (or Left) D/A converter in count per volt. When set to zero, the value is calculated from ARSC registry volts-full-scale value.

DA2_sensitivity = 0

Sensitivity of the second (or Right) D/A converter in count per volt. When set to zero, the value is calculated from ARSC registry volts-full-scale value.

MP_sensitivity=0.05

Sensitivity of the microphone in volts per pascal, when it is assumed to be constant for all frequencies. The value of this parameter for the ER-10C is 0.05, 0.5, or 5 depending on whether the GAIN switch is set to 0, +20, or +40 dB.

LS1_sensitivity = 21.5

Sensitivity of the first (Left) receiver (loudspeaker) in volts per pascal.

LS2_sensitivity = 27.75

Sensitivity of the second (Right) receiver (loudspeaker) in volts per pascal.

PRINTER Parameters

The PRINTER section begins with a line containing the word PRINTER in brackets like this: [PRINTER]. Parameters in this section relate to printing the contents of the screen. The following list of PRINTER parameters includes default values.

Label = Boys Town National Research Hospital

This causes the menu bar to be replaced by the specified label during printing. Replacement can be eliminated by an empty parameter setting “**Label=**”.

Orient = Landscape

Printing can be formatted in one of two possible orientations: Landscape or Portrait.

Port = screen.ps

The printer port, for a directly connected printer, may be specified by name, such as LPT1. Network printers may be specified by their network name (e.g., \\cellinux\lp). Instead of a port name or network printer name, this parameter may be set to a file name and screen images will be written to the specified file.

Type = PostScript

You can choose one of three printer types: PostScript, Color PostScript, or PCL. The PostScript output is suitable for including in other documents as an Encapsulated PostScript file. The PCL output can be used with HP LaserJet or HP DeskJet printers.

HEARING Parameters

The HEARING section begins with a line containing the word HEARING in brackets like this: [HEARING]. Parameters in this section apply to all hearing-threshold tests. The following list of HEARING parameters includes default values.

limit = 10

Artifact-reject threshold (mPa).

Level_start = 40

Starting level (dB SPL).

Level_step = 5

Step size (dB).

Freq_start = 500

Starting frequency (Hz).

Freq_stop = 40

Highest frequency (Hz).

Per_octave = 1

Number of frequencies per octave.

Tone_duration = 0.5

Tone duration (sec).

Min_gap = 0.5

Minimum time interval between tones (sec).

Max_gap = 1

Maximum time interval between tones (sec).

Response_time = 2

Maximum time allowed for positive response (sec).

Max_trials = 20

Maximum number of trials.

Min_sd = 3

Stop trials when standard deviation is below this value (dB). This stopping rule ignore when Algo=ANSI.

Simulate = N

Automate response using simulated observer (N, Y)?

Algo = UPDN

Adaptive tracking algorithm (ML, MEER, UPDN, ANSI).

Task = Y

Adaptive tracking task (Y/N, 2AFC).

Random = N

Randomize frequencies (N, Y)?

Connect = Y

Connect displayed symbols when results are plotted (N, Y)?

MinFz = 3000

Minimum notch frequency (Hz). [3000]

MaxFz = 13000

Maximum notch frequency (Hz). [13000]

Obn_max = 4000

Maximum frequency for the lowest notch frequency (Hz).

Cond_THL = THL

Conductance obtained from which type of file (TTH, THL).

Protocol = 1

Frequency set (1="standard", 2="F1, F2, Fd")

Scope = 2048

Number of waveform points displayed during calibration.

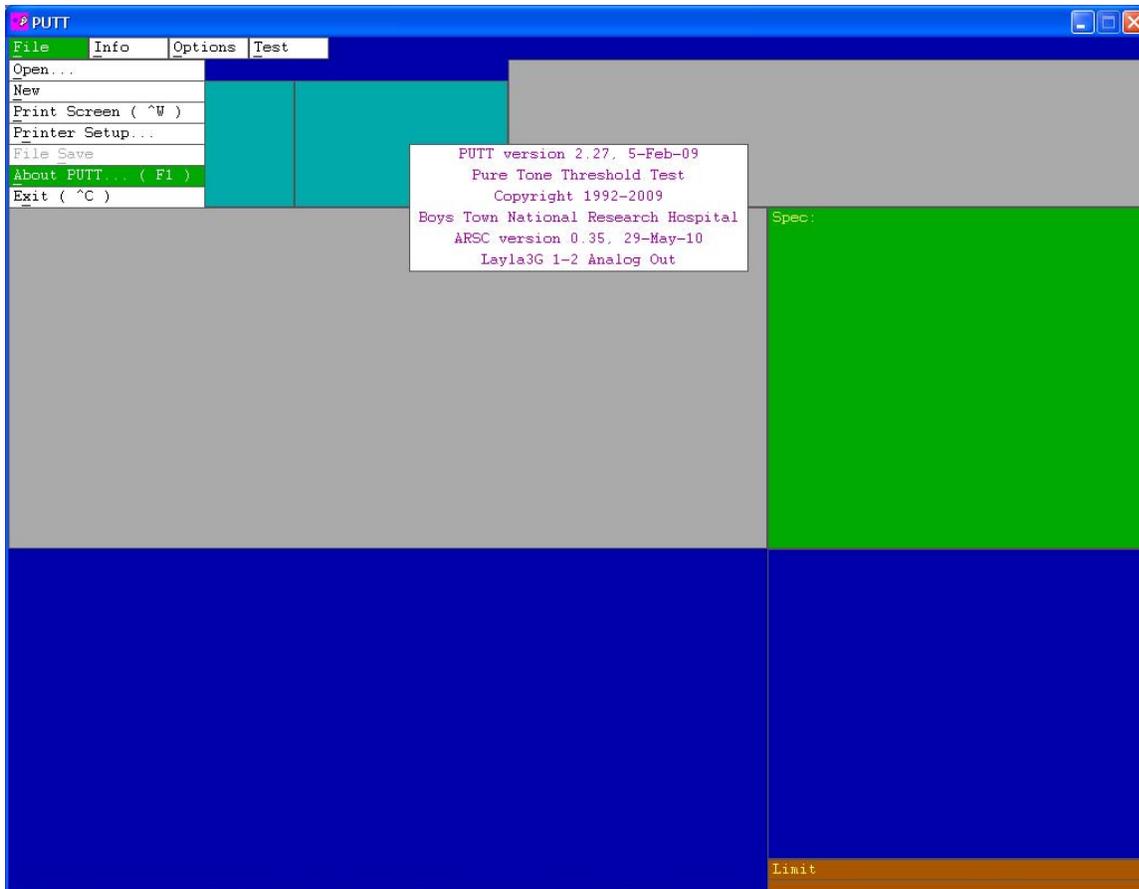
hfthr = N

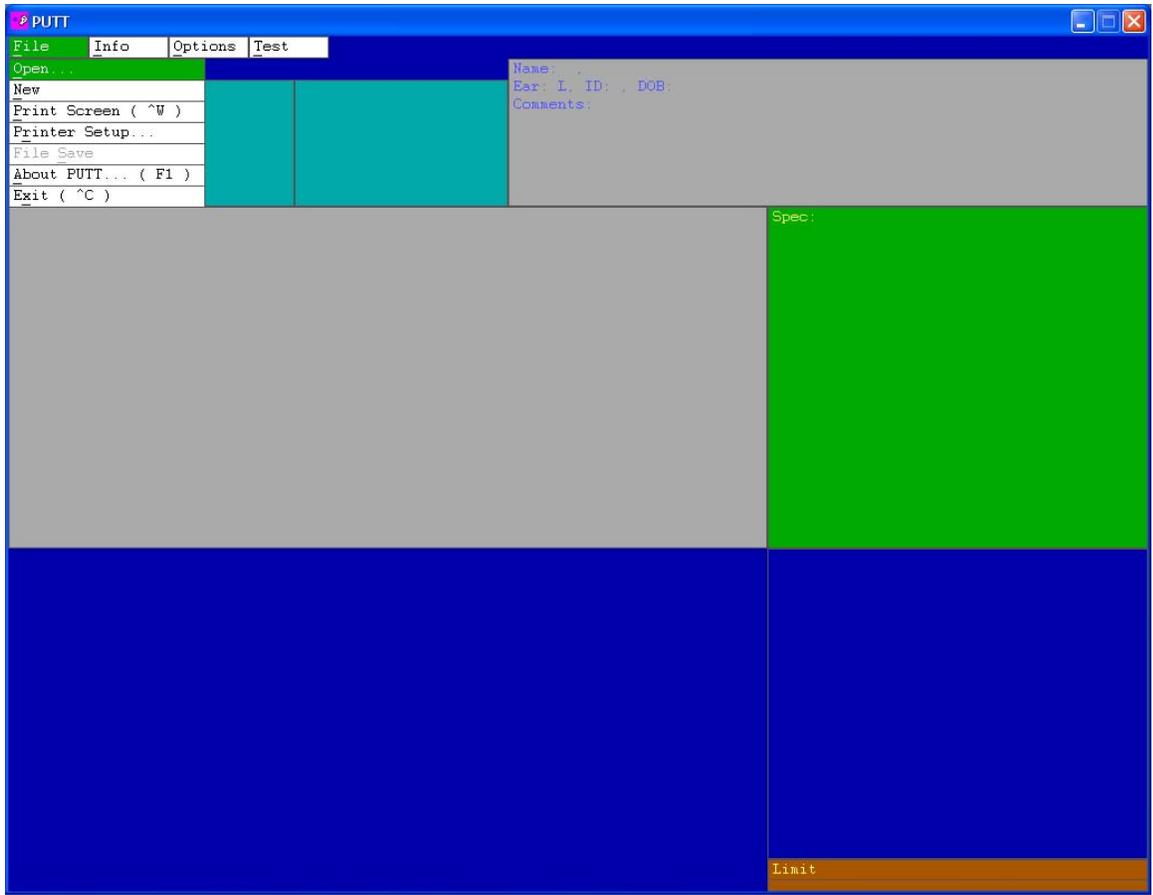
Add 9 & 10 kHz to "standard" set of frequencies (N, Y)?

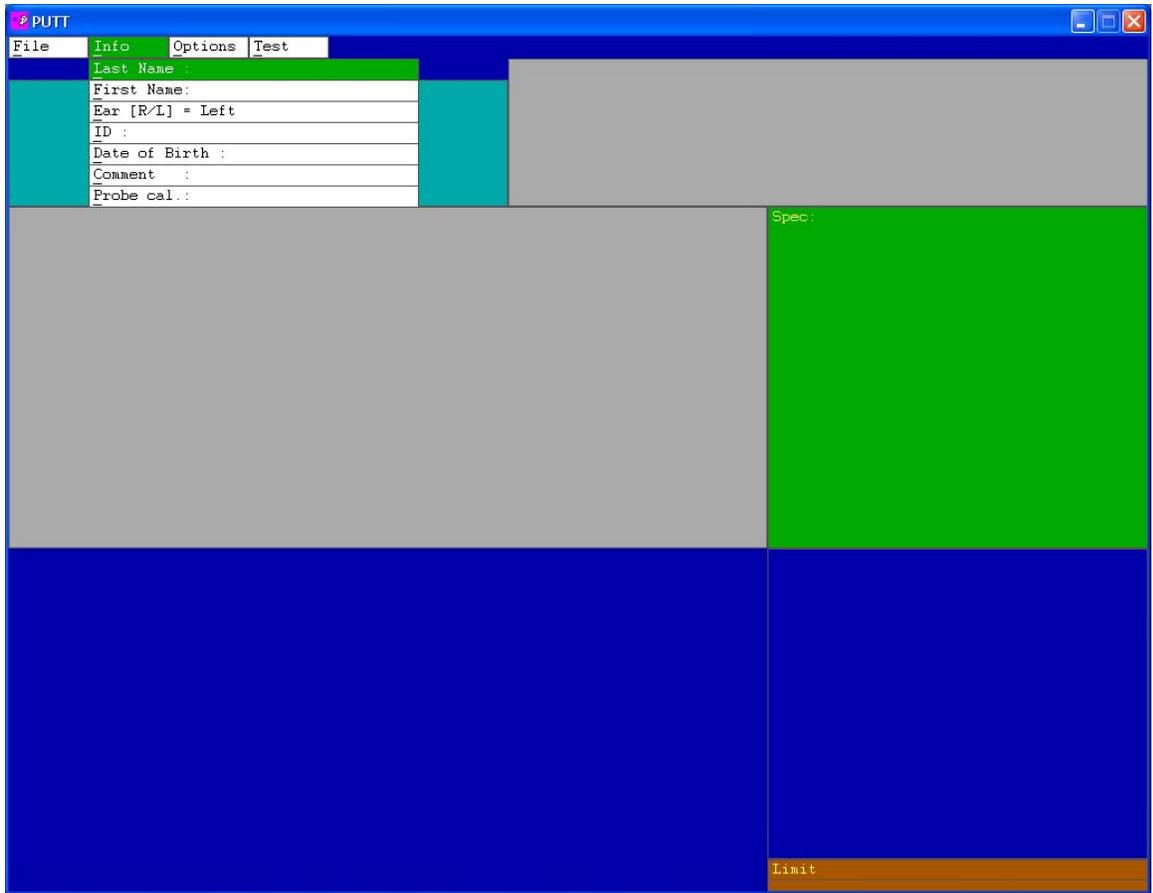
Freq_set = STD+NOTCH

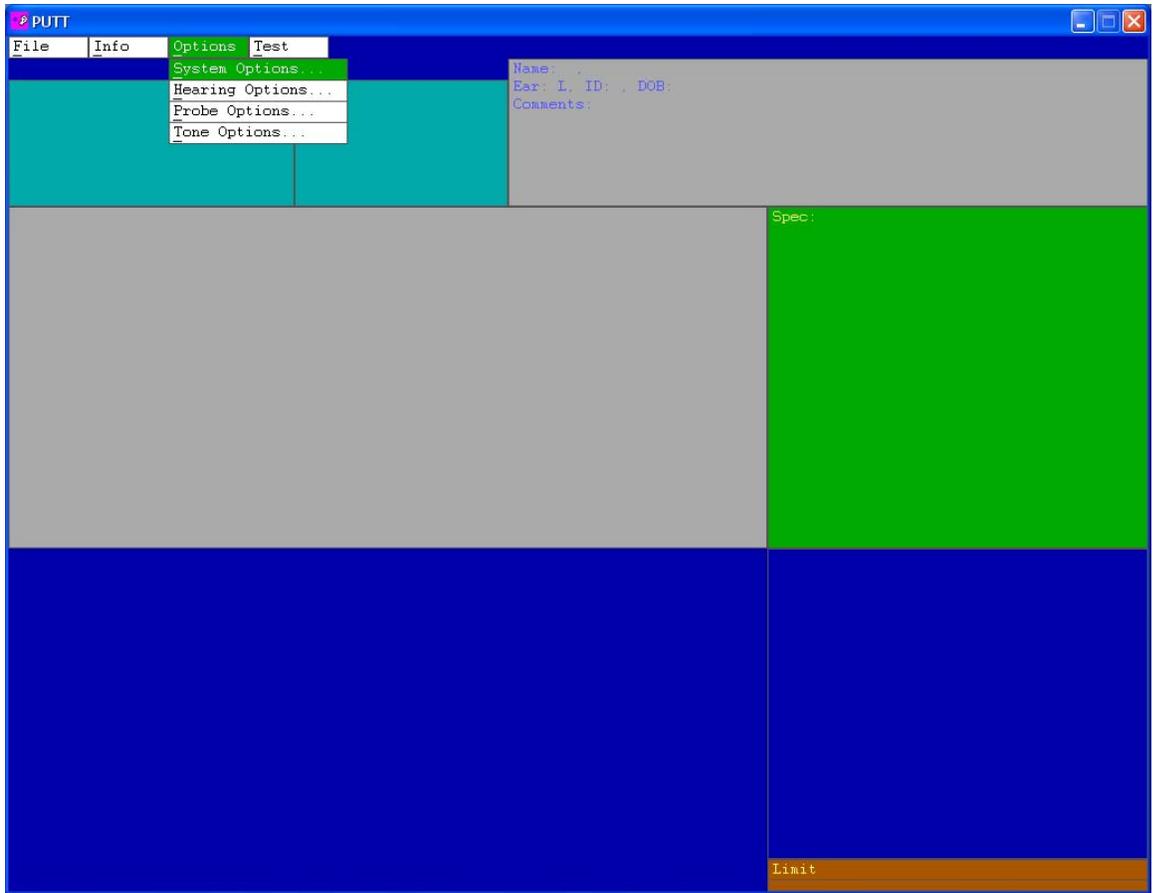
Set of frequencies (STD+NOTCH, STD, NOTCH, OPTIONAL). The STD set include the five frequencies (0.5, 1, 2, 4, 8 kHz) when hfthr=N and two additional frequencies (9, 10 kHz) when hfthr=Y. The NOTCH set includes 7 frequencies with quarter-octave spacing centered at the quarter-wave notch frequency. The OPTIONAL set is specified by the parameters Freq_start, Freq_stop, and Per_Octave.

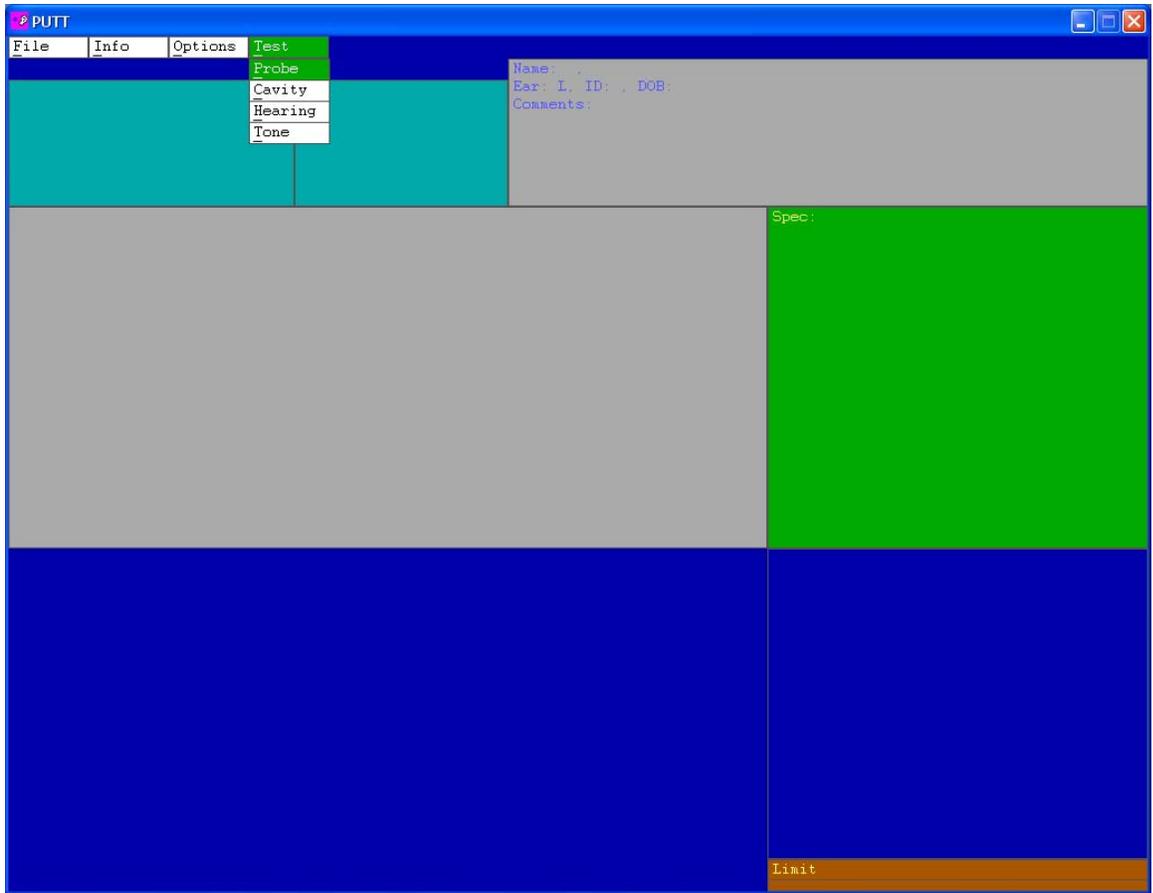
4. Screenshots











APPENDIX A: Program Installation

Windows. The most recent version of PUTT may be downloaded at <http://audres.org/downloads/putt-setup.zip>. Inside this zip file is an installation wizard (setup.exe) that will copy program files to your computer and place a shortcut on the Desktop.

It is recommended that you create a dedicated folder for PUTT data files. Edit the “Properties” of the PUTT shortcut on the Desktop to the “Start in” the folder that you’ve created for data files. Into this folder, copy putt.ini from “C:\Program Files\BTNHRH\PUTT\.” Edit your copy of putt.ini to specify local preferences for the values of PUTT parameters. Having your local changes to putt.ini in the data folder prevents them from being overwritten when a new version of PUTT is installed.

A User Manual is online at <http://audres.org/downloads/puttmm.pdf>.

Linux. The Linux version of PUTT is not yet available online. The PUTT program resides in /usr/local/bin. The configuration file (putt.ini) resides in the working directory, which is where data files created by PUTT will be stored.

APPENDIX B: SOUND CARD INSTALLATION

CardDeluxe

The CardDeluxe is manufactured by Digital Audio Labs. <http://www.digitalaudio.com/>

Connection of the CardDeluxe to the ER-10C requires three cables that each have a mono ¼" phone plug (TS) at one end and a BNC connector at the other end.

Windows. The CardDeluxe can perform synchronous averaging using its original MME Windows drivers.¹ In the device properties for this soundcard, the following configuration changes should be made.

Under the Configuration tab, set the "Record mode" to "lock to playback" and check to see that the "24-bit mode" is set to "left".

Under the Monitor tab, select only "Analog Output" in the Analog Output mixer section.

In the file putt.ini, set "DSP=W" for specify use of the Windows driver for this soundcard, set "DSP_code=", and set the soundcard sensitivity parameters according to the procedure in Appendix C.

Linux. The CardDeluxe is not usable under Linux because no ALSA drivers are available.

Indigo IO

The Indigo IO is manufactured by Echo Digital Audio. <http://www.echoaudio.com/>

Connection of the Indigo IO to the ER-10C requires two cables that each have a stereo 1/8" phone plug (TRS) at one end and two BNC connectors at the other end.

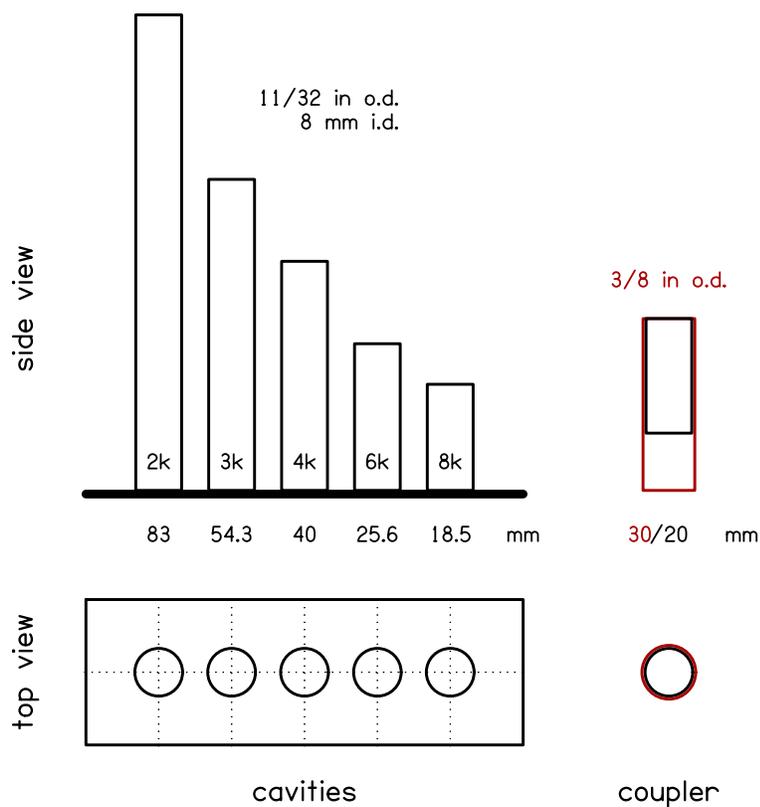
Windows. The Indigo IO has acceptable performance with the most recent WDM driver. The I/O synchronization is consistent more than 99% of the time with the WDM driver. The ASIO driver provides better I/O synchronization that is consistent 100% of the time. PUTT can use either the WDM or ASIO driver with the Indigo IO, but prefers to use the ASIO driver when it is installed.

Linux. The Indigo IO uses the ALSA driver under Linux and synchronizes I/O correctly in our tests.

¹ As of February 2008, we continue to use the (now obsolete) MME drivers because, in our tests, the newer WDM drivers would not synchronize record and playback consistently.

APPENDIX C: CAVITY CONSTRUCTION

The probe calibration cavities are constructed from brass tubing in the dimensions outlined below. A tube cutter is used to cut the brass tubes in the correct lengths. Super glue is used to attach the brass tubes to the base plate. Once the superglue is dry, epoxy resin is applied around the bottom of each cavity on the base plate in order to permanently adhere the cavities to the base plate. Super glue is used in the construction of the coupler.



APPENDIX D: CALIBRATION FILES

When PUTT performs in-the-ear calibration, the stimulus waveform and two microphone responses (one for each loudspeaker) are stored in a CAL file. When stimulus levels are specified in SIL or FPL, PUTT requires additional calibration files with extensions CAL, THS, and THL. All PUTT calibration file types have formats compatible with MATLAB (version 4) data files. Within the MATLAB program, use the option “-V4” to load MAT (version 4) files.

CAL

CAL files contain the ADC responses for either (1) a single acoustic cavity (typically an ear) or (2) a set of calibration cavities. These files are distinguished by the name of the first variable in the file, which either HEAR_CAL or PROBE_CAL. The variables contained in the two files are the same except for (1) the name of the first variable and (2) the number of instances of tokN, carN, stmN, and timN variables, where N is a sequence number that varies from 1 to the number of cavities.

CAL file variables			
name	length	Type	Description
HEAR_CAL or PROBE_CAL	1	Short	number of cavity response waveforms [1 or 5]
rate	1	Float	sampling rate (Hz)
npts	1	short	number of points in each waveform [2048]
info	33	Text	listener information
tok1	npts	Float	response waveform
car1	6	Float	reps, atten, pascal/count, temperature, diameter, volt/count
stm1	npts	short	stimulus waveform
tim1	1	Long	time of day
mesg	12	text	Left/Right ear indicator
Time	1	short	Test time (seconds)

THS

THS files contain Thévenin-equivalent source characteristics derived from a PRB file. Crosstalk pressure is optional in the computation of source characteristics and set to zero when not computed.

THS file variables			
name	length	type	Description
SRC_THV	1	short	number of frequency components (nf)
rate	1	double	sampling rate (Hz)
zs	nf+1	complex double	source impedance (cgs acoustic ohms)
ps	nf+1	complex double	source pressure (Pa/V)

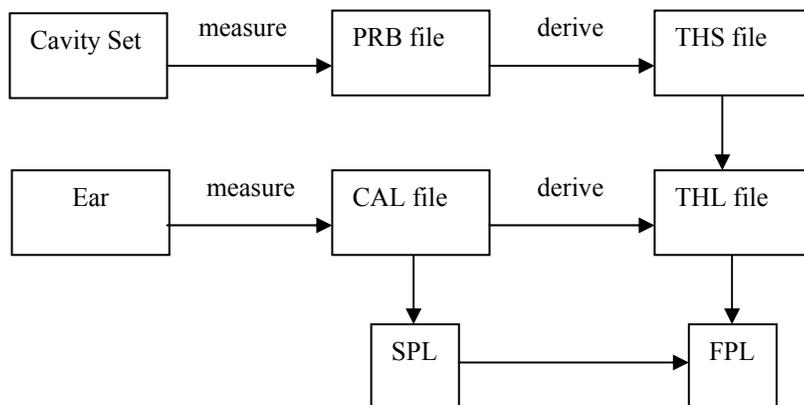
px	nf+1	complex double	crosstalk pressure (Pa/V)
df	1	double	frequency bin (Hz)
dc	1	double	cavity diameter (cm)
tc	1	double	cavity temperature (°C)
lc	ncav	float	estimated cavities lengths (cm)
sr	1	complex double	source reflectance

THL

THL files contain Thévenin-equivalent load characteristics derived from a CAL file and a specified THS file. Characteristic impedance has the same value at all frequencies. Load pressure represents desired pressure/volt for SPL calibration. Relative pressure represents desired pressure for SIL or FPL calibration divided by desired pressure for SPL calibration. Thus, relative pressure provides the scale factor required to convert an SPL calibration into an SIL or FPL calibration.

THL file variables			
name	length	type	Description
LD_THV	1	short	number of frequency components (nf)
rate	1	double	sampling rate (Hz)
df	1	double	frequency bin (Hz)
z0	nf	complex double	characteristic impedance (cgs acoustic ohms)
zl	nf	complex double	load impedance (cgs acoustic ohms)
pl	nf	complex double	load pressure (Pa/V)
pr	nf	complex double	relative pressure for SIL or FPL
tsf	12	text	name of THS file

The figure below illustrates how PUTT calibration files are related to each other.



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