TRUE TECHNOLOGIES

LIFETEST

Operator's Manual

Contents:

Rev 2.6

Appendix E. Using LifeTest with Switching Amplifiers

0.0 Caution!!!!

All users should be continuously mindful of these words of caution while using the LifeTest system. If not done properly, power testing at high power levels can be dangerous to the user and to the equipment:

- Only qualified and trained technicians should be allowed access to the system. A good understanding of electrical safety requirements is a must for anyone working with the system.
- Never make equipment connections while the equipment is powered up. Shut everything off (computer and all amplifiers) before installing or servicing the equipment.
- Never connect or disconnect loads on the amplifier output of any channel that is running.
- Never touch the speaker leads when the system is running. High voltages can be very dangerous and are potentially deadly.
- Use only amps that are short circuit protected. Otherwise, devices under test may fail and short out and cause damage to the amplifier.
- When calibrating, make sure only the test load is connected to the DUT output. If another load is still connected (a DUT still on that channel), the system readings will not be accurate.
- Don't forget to remove the test load from the LT box when calibration is complete. Leaving it in the circuit will cause erroneous readings (and may fry your test load.)
- If using the 4-Wire option, be sure to maintain polarity between amp, speaker/DUT cable and the voltage sense wires – See section 2.2 for more information.
- Refer to Appendix E when using Switching Amplifiers (i.e. Class D)

1.0 Introduction

The LifeTest system is designed to facilitate powered life testing of products drawing electrical current. Primary applications are the testing of passive loudspeaker transducers and systems, audio amplifiers, and powered loudspeaker systems. It is intended to be an economical system that is easy to use while offering a wide array of testing capability. The system software can accommodate up to 24 channels of simultaneous testing. It uses windows based audio device hardware and the LifeTest current sense box I/O as the only required hardware.

LifeTest works by allowing the user to set up test blocks that are groups of DUTs (Devices Under Test) subjected to the same test signal, power level, test duration and other attributes. All of the available channels can be set up as a single block or various combinations can be chosen. In the extreme, every channel can be its own block having a different power level, test signal, start/stop time, etc.

Test signals are stored as Windows wave files (.wav) and are selected from a drop down box when setting up a test block. Any file in the test directory is available for testing. The files can be generated from the LT application's signal generator module or from some other source including the recording of analog generators. Once the .wav files are available, there is no need for external gear; i.e., signal generators, CD players, filters, etc.

The calibrated system will output the required test voltage and monitor the current flowing in each channel. Duty cycling and power ramping is easy to setup. Small signal parameters of loudspeaker transducers can be measured at specified time intervals. Ambient temperature and humidity records can be tied to any test channel and temperatures of DUTs can be tracked as well.

1.1 Tips for Getting Good Performance From LifeTest

Like any measurement system, proper usage is required to get the best performance out of it. Following these tips will help:

- When calibrating, use a 2 or 4 Ohm load. This will help set the best EQ profile for the current sense transformers
- When calibrating, if your voltmeter doesn't auto-range, use the lowest range setting possible.
- When using the system to measure Small Signal Parameters, use as high of voltage level possible without pushing the DUT into excessive non-linearity. At frequencies below 100Hz, the current sense transformers perform best when 250mamps or more are flowing. For very small transducers where smaller currents are necessary, try to restrict the bandwidth to 100Hz and above. Make several manual SSP measurements to find the optimal settings for voltage and bandwidth that yield clean looking curves and repeatable readings.
- Try to reserve the LT computer for only making LT measurements when it is running. Leave as much memory available to the software as possible, especially when running long tests.
- Try to avoid using virus checkers, backup software, or other utilities that run in the background while LifeTest is running. The software is very processing intensive and can use a lot of memory when running long tests.
- Do not set Windows Update for automatic download and install. The install process will stop a LifeTest test and reboot your computer.
- Set the Power Settings in the control panel to best performance (not most efficient). Only allow the screen to go black – no hard disk spin down, sleeping, hibernating, etc.
- Do not use the dedicated LT audio devices (setup in the I/O form) for any other purposes. Do not install other audio devices and remove any old drivers from previously installed devices.
- If you are doing very long tests (>48 hours), consider breaking them into several shorter tests. LifeTest is designed to run much longer, but the audio interface hardware and/or Windows operating system issues will in rare circumstances cause problems. In most cases, LT will trap errors and reset accordingly, but testing for every possible scenario that can happen with different hardware platforms and different testing conditions is not possible. If you experience problems, please report the situation with as much detail as possible to True Technologies so the system can be improved whenever possible.
- Don't ever change connections between the equipment (including the computer) and/or the DUT while the test is running. For wire changes between equipment, shut the power off to the amplifiers.
- When using PWM amplifiers (e.g., class D) that have high frequency switching ripple, a low pass filter must be used between the test load and the voltmeter used in calibration. See appendix E for more detail.

2.0 System Setup

2.1 Software Installation. Install the LT software before connecting the LT box. The install procedure will install the drivers for the LifeTest enclosure and this ***must*** be done before the box is connected to the PC via the USB cable. Running the setup.exe file will simultaneously install the LifeTest system and the security dongle drivers. It is strongly recommended that you close other applications on the desktop while doing the install. A successful installation will leave short cuts to the software on the desktop and the in the startup menu.

2.2 Hardware Setup. Next install the audio interface according to the manufacturer's instructions and verify the device is functioning properly by looking for the audio devices in the Windows control panel. The audio interface can be any device that offers Windows legacy drivers that present the audio devices as stereo pairs to Windows. The hardware can be PCI card based or connected by USB or Firewire cable.

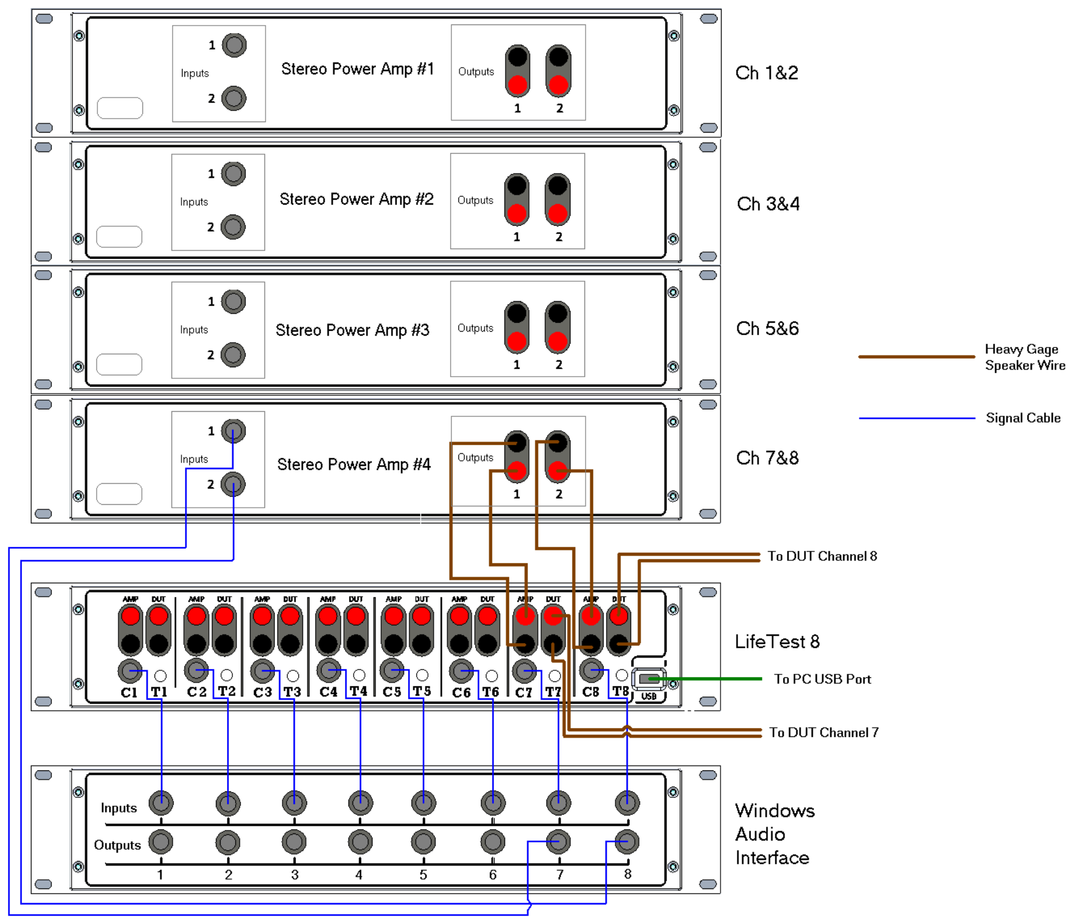
Note, the signals returning to the audio interface inputs from the LT C/V outputs are not associated with the same DUT #. To maintain 8 channels per unit with simultaneous current and voltage measurements, each DUT channel uses two LT ouputs that are shared with another channel through a relay. The routing is as follows

DUT 1 / 5 -> LT C/V 1 / 2
DUT 2 / 6 -> LT C/V 3 / 4
DUT 3 / 7 -> LT C/V 5 / 6
DUT 4 / 8 -> LT C/V 7 / 8

Hence, even if you are monitoring a DUT only on channel 1, LT C/V outputs 1&2 must both be connected to the audio interface inputs according to the routing of the I/O setup as discussed in section 2.5.

2.2.1. Wiring The LifeTest Box. The LT C (current monitor) output jacks are unbalanced, but they will work with an audio device that has balanced inputs. The calibration routines account for the gain loss.

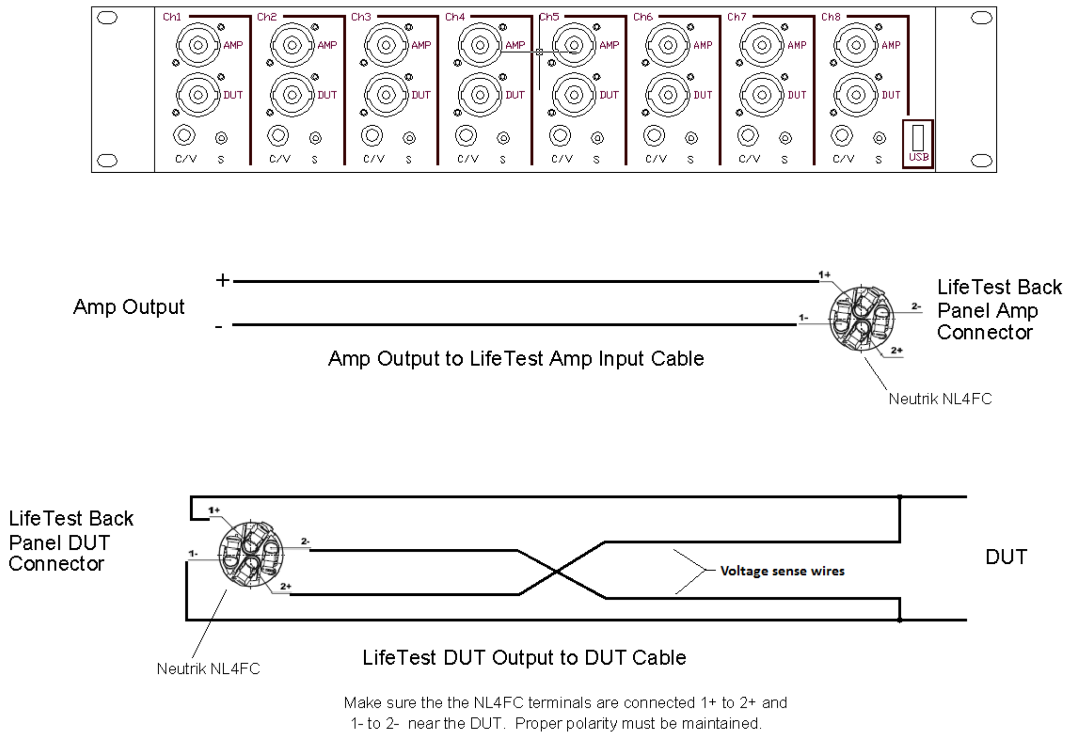
The system setup is straightforward. The first step is to hook up the components as shown in the typical configuration of the diagram below. (For the 4-Wire option see the next graphic.) The speaker cables and signal wires are shown only for channels 7&8 for clarity. The LT USB jack must be connected to the PC USB jack using the provided male-to-male USB cable. This cable connects the USB security dongle to the PC and without it the system will run only in demo mode and no actual testing can be done.



System Configuration

The 4-Wire configuration is shown below. In this setup, the voltage measurements are taken from a point near the DUT. This gives the most accurate readings as the voltage drop in the cables to the DUT are not an issue. This option is recommended where highly accurate test voltages are required and in cases where long cables are driving relatively low impedance loads. This version of LifeTest can correct for the cable losses. Only Neutrik NL4FC connectors should be used to connect to the LifeTest back panel for the 4-Wire option. Other connectors may not fit properly or may not have adequate current handling capacity. Be sure to wire the LifeTest to DUT cable as shown below. Maintaining proper polarity between the Amp, LifeTest, and the voltage sense wires is very important! Failure to wire as shown can result in erroneous measurements or possibly equipment damage.

LifeTest 4-Wire Option



It is recommended that power amplifiers be used that provide more than adequate head room for the worst case current and voltage requirements. It is not necessary that all amplifiers be the same. It may be desirable/more cost effective to purchase just one very high power stereo amp that is capable of meeting the worst case current/voltage need. However, such a strategy can limit channel usage flexibility.

It is also recommended that all external equipment be kept in an equipment rack to keep wiring neat and organized. If the amplifiers or audio interface have knobs or buttons that will affect output/input levels, the rack should have a lockable screen door that prevents tampering or accidental adjustment of the system after it has been calibrated. Make sure any door allows for adequate air flow as intended by the amplifier manufacturer.

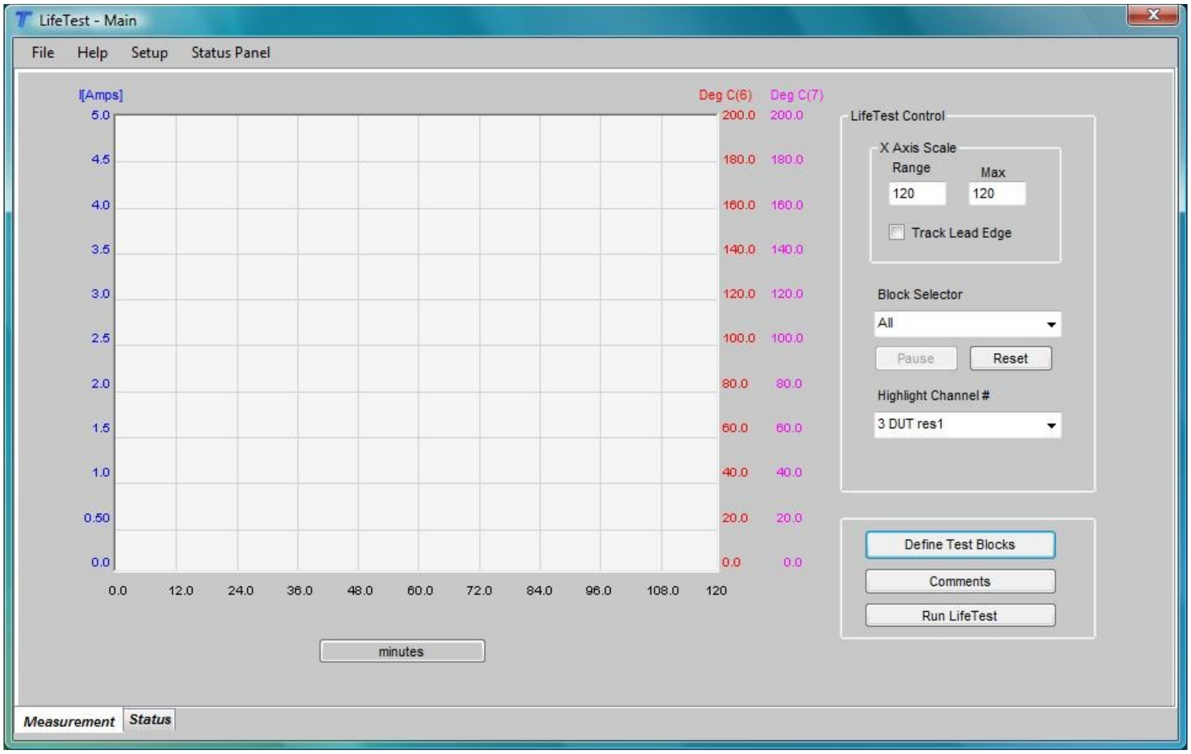
The speaker cable gage should be heavy enough to support the maximum expected current and to keep the total run (Amp-LT-DUT-LT-Amp) impedance at a small percentage of the lowest DUT impedance to be tested (this is less critical when using the 4-Wire option.) For example, if the amp is 1 meter from the LT box and the LT box is 5 meters from the DUT, the total impedance is (1+5)*2 = 12 meters. As can be seen in table 1 below, using 12AWG wire provides adequate current capacity, but when driving a 2 Ohm load the voltage drop in the wire will be about 3% which is probably too high. 10AWG wire reduces the drop to about 2% and 8AWG reduces the drop to around 1%. In reality, the drops will be less than this for typical transducer loads. The LT system puts out a voltage based on the system calibration and rms level in the wav file. Care should be taken to avoid excessive voltage drops in the speaker wire (again, less critical with the 4-Wire option, though the Max continuous current should never be exceeded.)

AWG wire gage	Max. continuous current (Amps)	Approximate resistance milliohms/foot	Approximate resistance milliohms/meter
16	19	4.0	13.1
14	27	2.5	8.2
12	36	1.7	5.4
10	47	1.0	3.3
8	65	0.6	2.1

Table 1. Wire gage current capacity and resistance

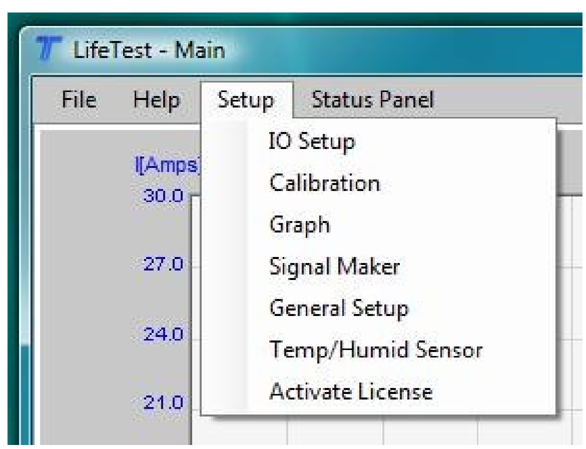
2.3 Activating the Software. When everything is connected and the audio devices are confirmed to be installed, the software can be started. If the software does not find the security dongle installed within the LT box, the software will run only in demo/viewer mode. The first time program startup will require a validation code. Follow the instructions given and email the request given to the email address provided. A return email will provide the validation code needed to fully activate the system. The computer system clock/date must be accurate or the code will not work. Depending on the license agreement, the activation code might be need periodic updating. A warning will be given when the license needs updating within the coming 30 days.

Whether the system is fully activated or running in demo/viewer mode, the main screen will open as shown below.



LifeTest Main Screen

The setup drop down menu shown at the right is used to open the calibration and audio I/O devices windows. These setup steps must be done before the system can be used.

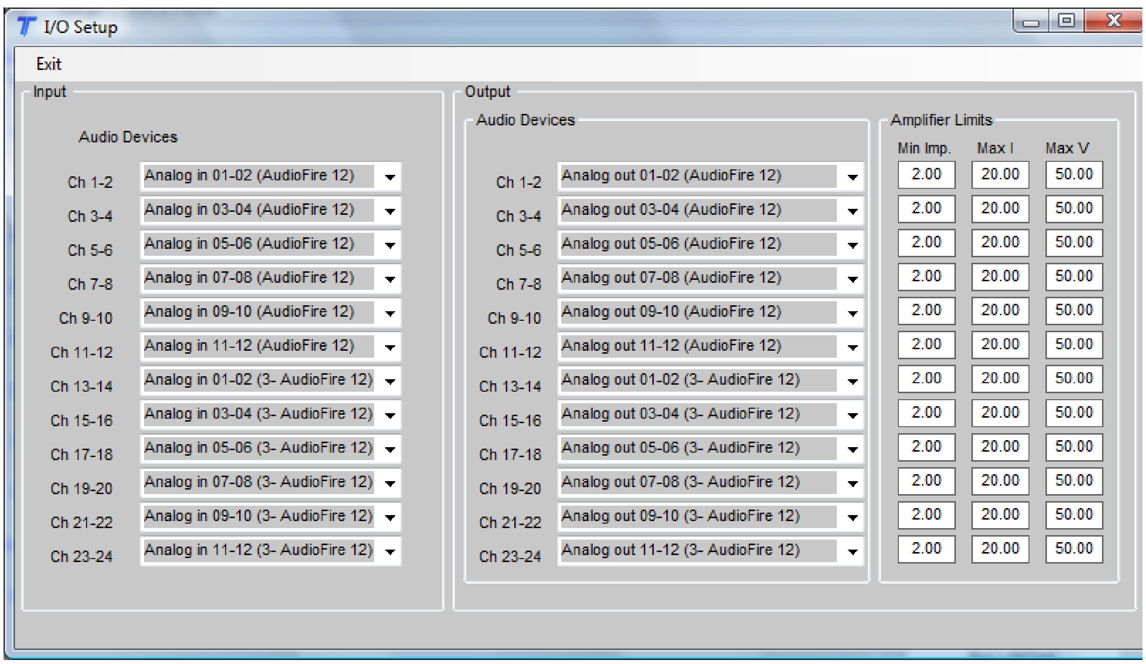


Setup Menu Options

<u>2.4 Password Protection.</u> The setup options can be password protected by creating a text file with the desired password saved on the first line in a text file named USER.PWD in the “\PTSetup\” subdirectory of the LifeTest application. For calibration, I/O Setup, and

General Setup functions, the user will be prompted for the case sensitive password. The password scheme is not intended to provide high security, but rather to keep untrained operators from accidentally changing setups.

<u>2.5 I/O Device & Amplifier Settings.</u> Start with the I/O Setup screen as shown below. The input and output devices registered with Windows will be available for selection from the input and output drop down boxes. The inputs and outputs are routed as stereo pairs. Device1-2 must be used for channels 1-2 for both inputs and outputs and so on.



Configuring the I/O Devices and Amplifier Limits

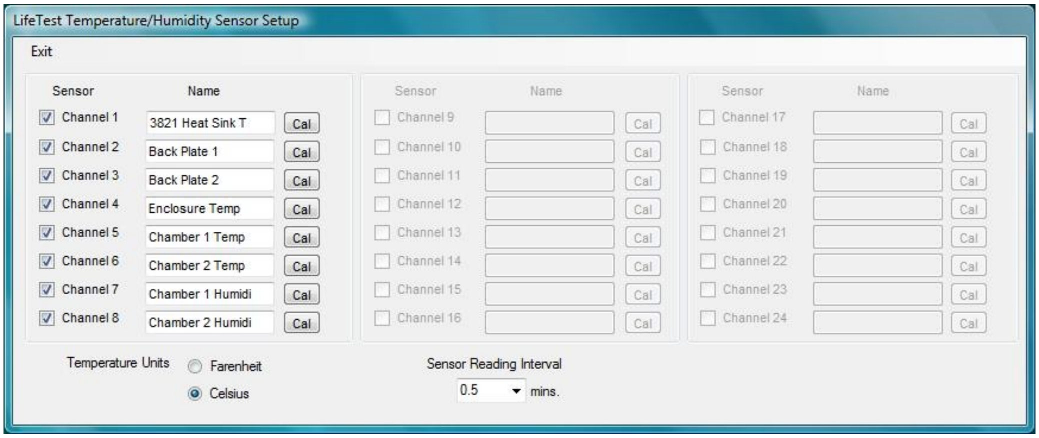
The I/O setup screen also has boxes to enter the minimum impedance each stereo amplifier is capable of driving along with the maximum current and voltage it can provide. The settings can be determined from the amplifier specifications but it is recommended that distortion versus power measurements for the range of anticipated loads be made to determine these settings. The maximum current allowed is 30 amps (rms) that is the rating for the current sense electronics in the LT box. When setting up test blocks, the system requires entries for the DUT minimum impedance and test power level. The maximum current and voltage requirements are calculated and the system will not allow any block to be saved that violates the limits setup on the I/O setup screen. This feature is included to prevent technicians not familiar with the amplifier capabilities from attempting to run a test that might give faulty test data or damage the amps. Note: each pair of amplifier channels can have different limit entries.

Once the options on the I/O screen are set, they will be permanently saved until they are changed through the I/O Setup menu option.

2.6 Calibrating the System. Next, the system requires calibration. Click on the Calibration option from the Main Screen menu option to see this window open. To calibrate a channel, simply select it and click the Calibration button. An accurate true rms reading voltmeter and a power resistor (recommended 10W or higher) with precisely known impedance are required. To begin, the user is prompted to connect the calibration load to the LT box dual banana DUT outputs. **Make sure there is no other load connected.** The system will play a very low level tone through the selected channel output and the user is prompted to enter the measured voltage. The system then plays a second tone that should be near 1.0Vrms and a second measurement value is requested for fine tuning. At this point, LifeTest will continue the routine for the selected channel by playing a multi-tone signal used for system equalization. Finally, a last tone is played to measure the current through the test load as represented by the input to the audio device from the LT box CMON output. The entire process should take less than one minute per channel. They system will not allow a channel to be used for testing if the calibration process has not been completed.

Calibration Screen for 8 channel System

If temperature or humidity testing will be used, then open the Temp/Humidity setup screen shown below.



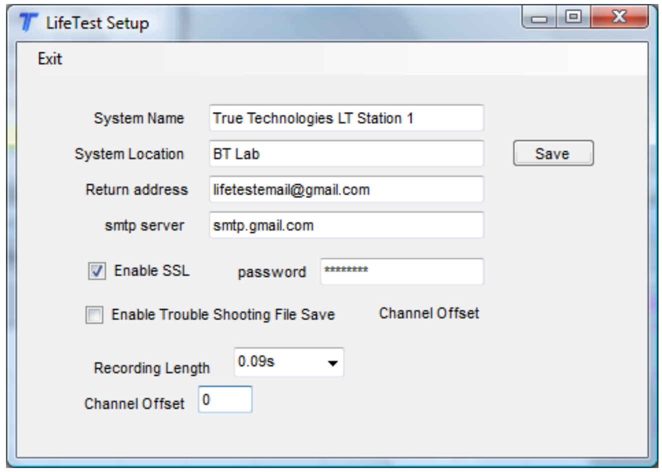
The number of channels available (enabled) is equal to the number of LifeTest channels activated. A channel must be calibrated before it can be used. First, click on the Cal button and then follow the instructions. Channels 7 and 8 (and 15/16 – 23/24 when more than one LT box is used) can be configured for temperature or humidity. When calibrating these channels, the system will ask what type of sensor you are using. Enter (H) for Humidity or (T) for temperature.

For temperature calibration, hook up the probe to the appropriate jack in the back of the LT box. Let the sensor acclimate to its surrounds for at least 15 minutes. The environment should be fairly stable with constant temperature or humidity. An accurate thermometer or hygrometer is needed for calibrating temperature or humidity respectively. For temperature calibration, enter the value of the reference sensor when prompted. For humidity calibration, the reference value is needed along with the slope and offset numbers provided by the IC manufacture (provided by True Technologies.)

Once the device is calibrated, give it a name that is easy to identify with. The box must also be checked if the sensor is to be monitored during the current test. Otherwise, it will not be available when setting up a test block.

Any time a device is moved to a different channel, it must be re-calibrated. The temperature probes are interchangeable within 5% so a 10% error is possible if the channel calibration factor is not updated after moving the probe.

2.7 General Setup. The figure below shows the General Setup screen that is also selected from the Main Screen Setup Menu.



The system can be given a name and the location can be noted in order to differentiate if from other systems. This can be useful when using the remote monitoring or email reporting functions (see section 4.) For email reporting, the return email address and SMTP server must be entered along with the account password. Return addresses setup as Gmail accounts work well with the .SSL enabled.

Note, the recording length was changed in Rev 2.5 to be a global parameter. It is no longer applied to individual blocks. This parameter dictates how many samples are collected for calculated the current and voltage values. A shorter value will yield a more responsive system (usually not necessary in power testing) and a longer recording will provide more smoothing and readings closer to the long term rms current and voltage values.

The Channel Offset value can be set to 24 on a second system if there is more than one 24 channel system at one site. The channels on the second system will then be denoted as 25-48. This can help to avoid confusion, especially if a KVM switch is being used to control both computers – sometimes it's easy to forget what computer is being viewed.

3.0 Signal Generation and Management

After the I/O setup and Calibration is complete, the system is ready to be used, but before setting up a test block can be done test signals must be available to choose from in the "\PTest Signals\" subdirectory. There are a few requirements for the Windows .wav files to allow them to be used as a test signal:

3.1 Rules for Test Signal Wave Files

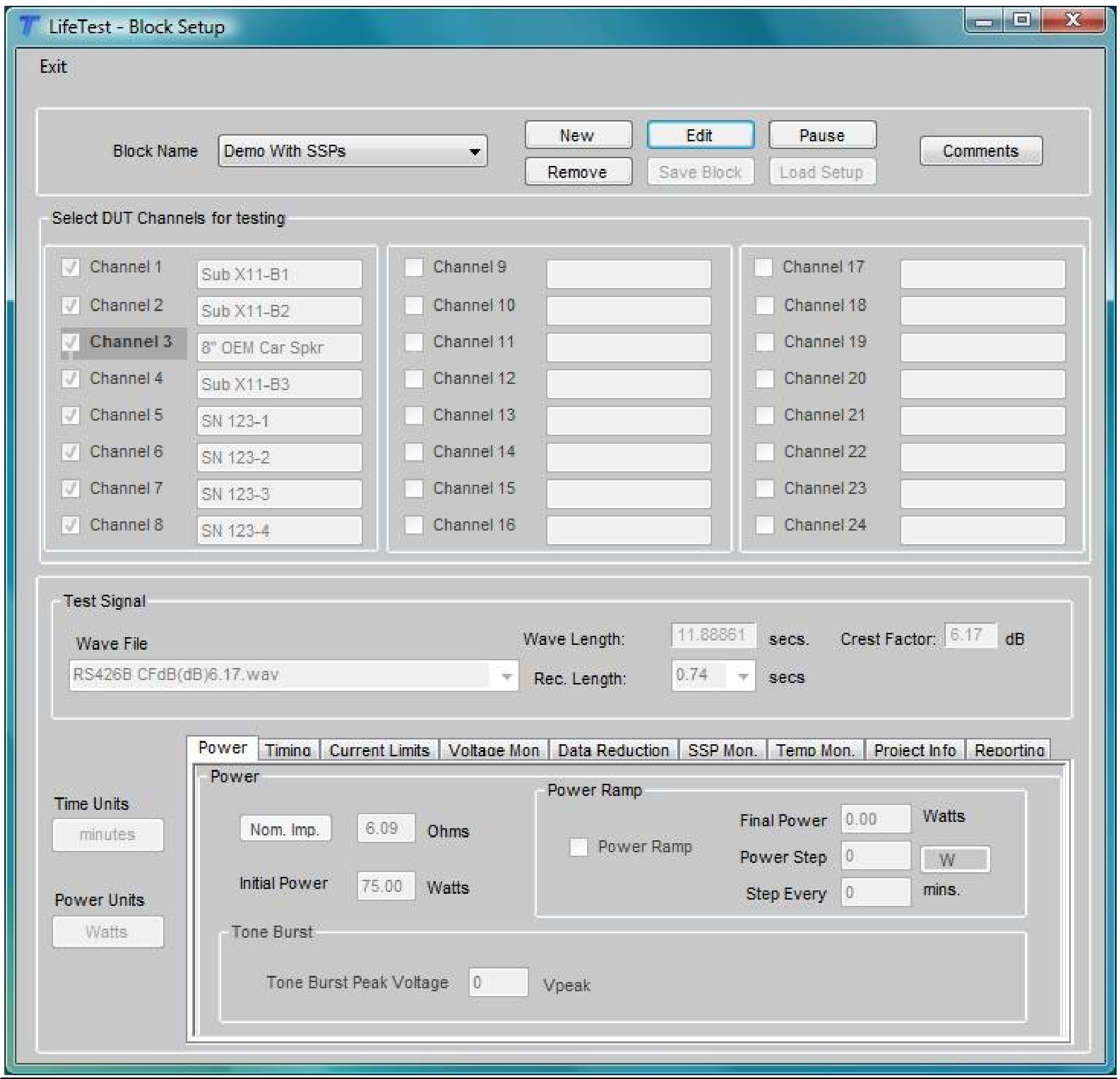
- Must be 44.1kHz sample rate
- Must be mono/16 bits
- If the number of samples in the file are *not* of length 2^n where n is an integer, then adjacent stereo paired channels (e.g., 1&2, 3&4, etc.) must be in the same block (in other words, use the same signal.) The software will enforce this rule. It is best to use files that follow this scheme to maintain maximum flexibility. For steady state signals (like tones), n can be small so the file is short. For example, with n = 12 the file will be 4096 samples long (or 0.09 seconds at 44.1kHz.) For random signals like pink noise, it is recommended to use a file long enough so that the statistics of the signal reflect the long term expectation (proper spectral content and crest factor.) However, do not make the signals so long that they are difficult to manage. Very long files will slow down the processing needed to prepare the signals for test. Choosing n = 19 usually works well and results in an 11.9 second signal that has good statistics.
- The spectral content of the signal should not contain significant energy outside the bandwidth of the system. The software calculates the rms content in the .wav file and uses the calibration factor to adjust the signal level output to the DUT. This is a convenient and accurate way to set levels as long as the signal chain (audio playback device or amplifier) has adequately wide bandwidth. For example, a .wav file with true pink noise has energy content down to DC. Obviously, some of the energy will not make it through an amplifier with a -3dB frequency of 10 Hz and the resulting rms output voltage can be a bit low (typically 1-3%.) To avoid this situation, pre-filter the signal so it has a roll off characteristic similar to that of the amplifier. When used the voltage correction feature will account for the roll off to make the rms voltage right, but the spectral characteristic of the signal will no longer be as intended (as with any power test system that has amps with inadequate bandwidth.)
- When using tones or multi-tones, the frequencies should be chosen so that an integral number of cycles are included (i.e, on the bin frequencies in the 2^n FFT that has frequency spacing of $44{,}100/2^n$.) This will ensure the end and beginning of the file match in sample value and wave slope and when the file is looped there will be no pops/clicks due to a mismatch. The Signal Generator function described in the appendix ensures this will be the case.

As long as the .wav files follow these rules they can come from any source. The can be digitally generated with any .wav editing/creation algorithm or they can be recorded from signal generators. The files only need be placed in the aforementioned subdirectory and they will be available for selection when setting up a test.

The LifeTest application software comes with a Signal Generator Module (SGM) to help create typical power test signals. Most signals required for industry standard tests can be created using this tool. See Appendix A for the tips on how to use the SGM.

4.0 Preparing A Test Block

To prepare a block of DUTs for testing, click on the Define Test Blocks button on the main screen. The window shown below will open. In this example, 3 different blocks have been setup. When you choose a previously setup block from the drop down, the channels selected will be highlighted and the setup parameters will be updated.



Block Setup Screen.

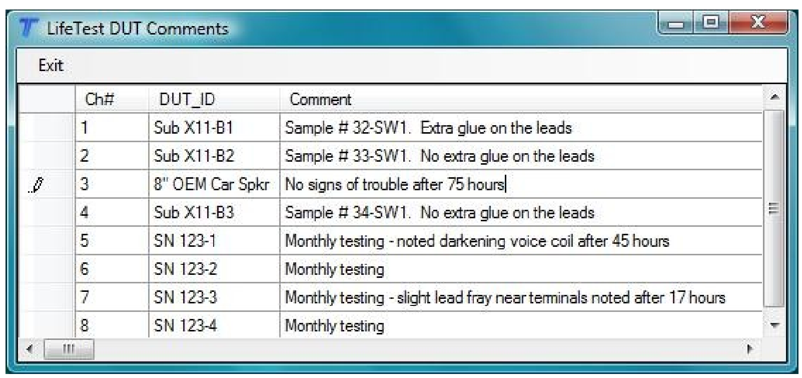
To add a block for testing, click the New button and provide a name as prompted. If a previously setup test parameters are to be used, then click the Load Setup button and use the file manager to browse to the setup file. When opened, the setup parameters are automatically filled in except for the channels to be used.

Click on the boxes indicating what channels will be included in the test. All channels in the block will be tested with the same parameters – test duration, power level, test signal, etc. To change a block, click the Edit button. However, after a test is started, the block setup cannot be changed. This ensures the data generated will be only the result of the settings of the given block and not some previous iteration. (Comments can be changed after testing has begun. This allows the user to make notes of observations made during the test.)

4.1 Channel Setup. The number of channels available (enabled for selection) depends on the number activated with the security dongle according to the purchase agreement. In the example above, eight channels are activated. LifeTest can be activated as an 8, 16, or 24 channel system.

Adjacent channels 1&2, 3&4, etc. are stereo pairs in the audio interface. Any channel used with tone burst testing can only have the same tone burst signal in the adjacent stereo paired channel. The software will police this requirement and not allow a setup that doesn't work. Otherwise, there are no restrictions dictating what channels can be used in a block. All channels can be assigned to a single block, or every channel can be its own block with completely different settings.

Each channel can be given an ID (e.g. serial number) and a grid for more detailed notes is presented when the Comments button is clicked. This grid is available from the Main Screen as well and notes can be edited to record observations throughout the test. The comments can be sorted by clicking on a column header.



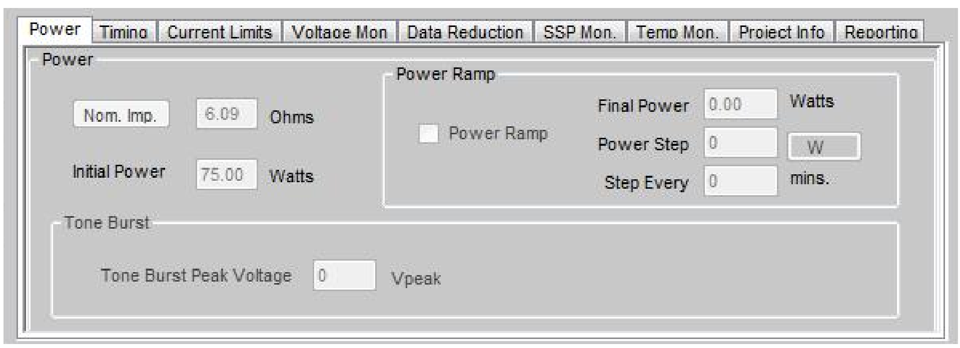
Ch#	DUT_ID	Comment
1	Sub X11-B1	Sample # 32-SW1. Extra glue on the leads
2	Sub X11-B2	Sample # 33-SW1. No extra glue on the leads
3	8" OEM Car Spkr	No signs of trouble after 75 hours
4	Sub X11-B3	Sample # 34-SW1. No extra glue on the leads
5	SN 123-1	Monthly testing - noted darkening voice coil after 45 hours
6	SN 123-2	Monthly testing
7	SN 123-3	Monthly testing - slight lead fray near terminals noted after 17 hours
8	SN 123-4	Monthly testing

4.2 Basic Block Info. After setting the channels, next choose the test signal wave file from the drop down box. If you are doing tone burst testing, the signal name must begin with TB (the SGM takes care of this automatically with its save routine.) Wave files in the "\PTest Signals" directory will be available for testing. See section 3.0 for wave file requirements and information on creating them. When the wave is selected, the wavelength in seconds is displayed as is the crest factor.

Next select a recording time from the drop down Rec. Length. This is the time sample used to calculate the rms current for each channel. The choices range from very short (0.09secs) to fairly long (1.49secs.) If the recording length is set equal to the wave length, the measurement will be very smooth. If the recording length is shorter, there will probably be some choppiness noted due to different snapshots of energy captured with each measurement. For very long waves, the longest measurement at 1.49 seconds will only capture a fraction of the wave. However, for signals with constant statistics the data will normally still be fairly smooth. A shorter time window might be desirable for better responsiveness in the data.

The parameters of the test are set with the tabbed box near the bottom of the window. The buttons to the left of the box allow for selecting entry units for time (seconds, minutes, hours) and signal level (Watts, Volts.)

4.3 Power Settings Tab. Set the power requirements on the first tab as shown below.



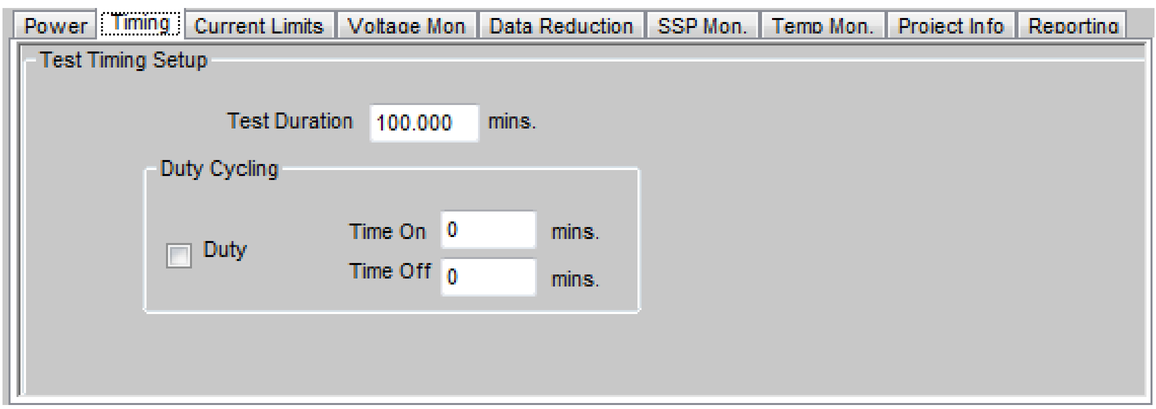
The nominal impedance is required so the system can check the limits on current and minimum load (as setup on the I/O Setup screen in section 2.) If the power is entered in Watts, the nominal impedance is used to calculate the output voltage setting.

If the nominal impedance value is not known, click on the Nom. Imp. Button and the screen to the right will pop up. The channels selected for testing in this block with be available for selection from the drop down box. Enter the minimum and maximum frequencies to define the search range. LifeTest will measure the impedance throughout this range using a binary search algorithm to find the minimum impedance. When the algorithm is complete, click the Transfer Value button to have the Zmin value automatically transferred to the Power Screen.

The initial power and nominal impedance values are the only ones required. If it is desired to use the power ramp feature, additional information is needed. Check the Power Ramp box and enter the Final Power level, Power Step, and the Step Every values. Click on the button aside the Power Step text box to select the units for each step (vrms, dBV, Watts, dBW.) See the next section for an example of using the Power Ramp feature together with Duty Cycling.

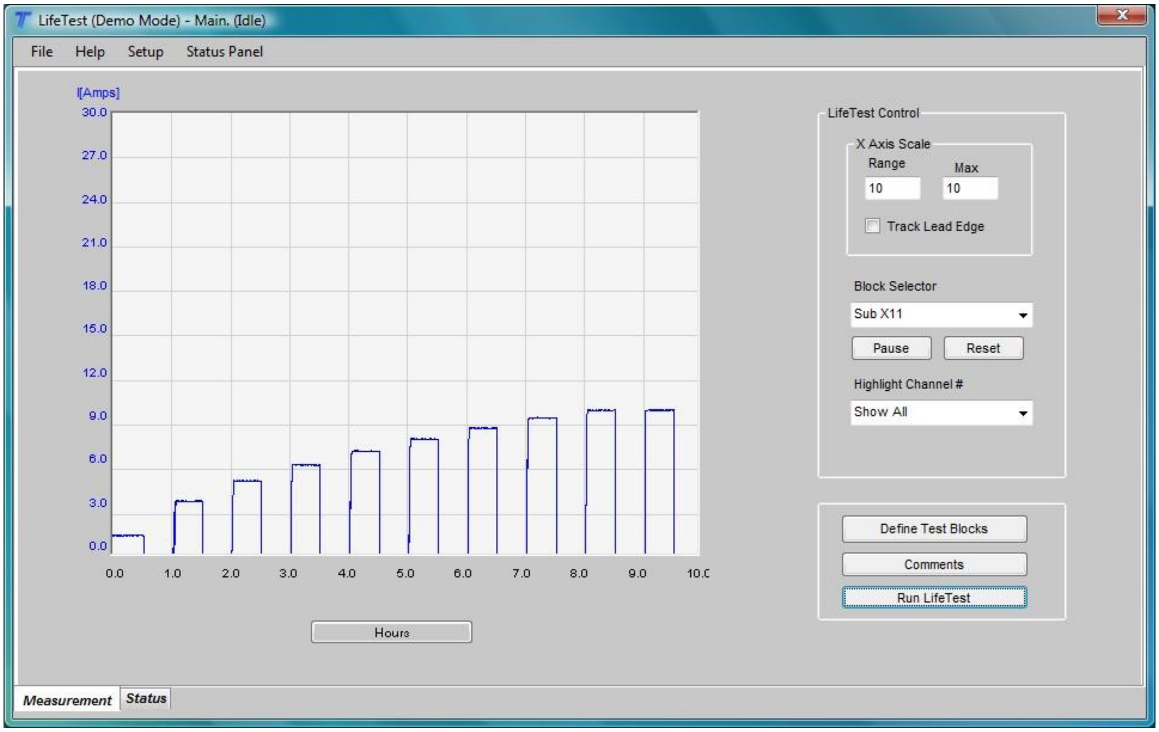
When a Tone Burst signal is selected (as denoted by a TB prefix), the only required Power setting is the burst peak voltage. The Power Ramp feature can be used with tone bursts as well but the levels are set in peak voltage instead of power..

4.4. Timing Settings Tab. The timing tab is shown below.

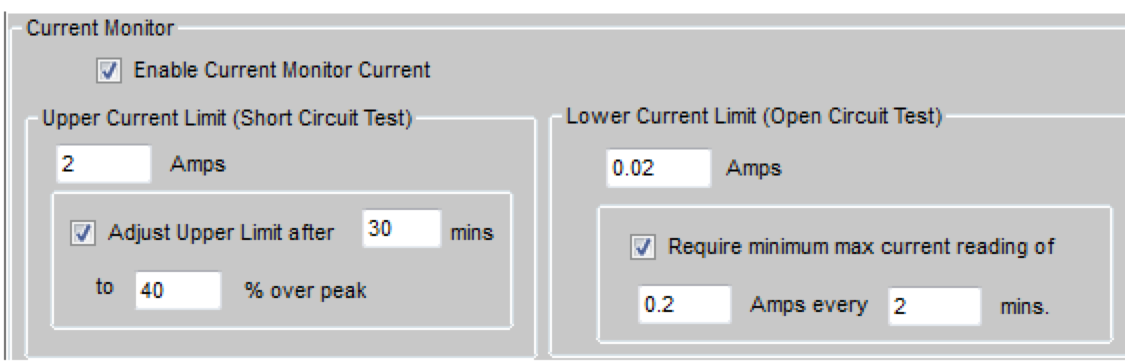


Timing Tab in Block Setup.

The Test Duration is required. The system can be set to Duty Cycle on and off by checking the box and entering the on and off times. This is useful for testing effects of stresses on a DUT from heating/cooling cycles or to allow the DUT to recover before repeating a test or increasing the power level. This feature can be combined with the Power Ramp. Simply set the Power Ramp timing to be On+Off time and with each new On cycle the power will step up (or n*(On+Off) ramps up every nth cycle.) Combining the Duty Cycling and Power Ramp features is an effective way to determine the power rating of a device. Below is an example of a 4 Ohm woofer being testing with ½ hour on/off cycles with power increasing in 50W steps from 10W to 400W.



<u>4.5 Current Limits Tab.</u> Next set the Current Limits if desired with the tab shown below

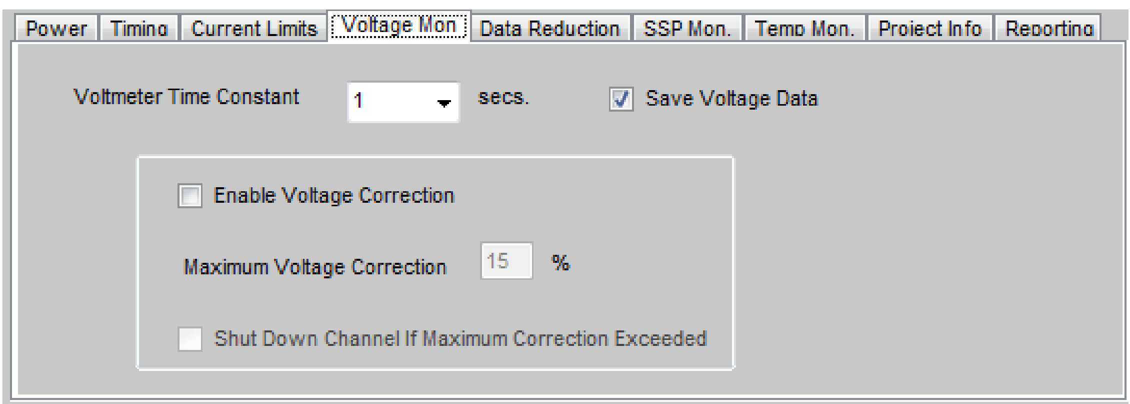


Current Limits Tab in Block Setup.

By checking the Enable Current Monitor box, the system will check each current reading against the entered limits and shut the system down if it is outside the limits (actually, a second reading is taken immediately upon failure to verify the reading was valid.) If the current measurement exceeds the upper limit, a failure mode of short circuit will be noted. If it drops below the lower limit, the failure is reported as an open circuit.

In some cases it is not immediately obvious what the limits should be set to. The rms current measurement will be some value based on the integrated impedance response and voltage spectrum and will always be lower than the value calculated from the minimum impedance. If the Adjust High Limit After box is checked, the system will automatically set the upper limit based on the entered percentage over the peak found in the first t minutes where t is taken from the box provided (30 minutes in this example.) For steady state signals the % Over Peak value can be small (e.g., 10%), but for signals like high dynamic range music the value should be high to prevent false limit trips (40% usually works well.) The Lower Current Limit might need to be set to zero if a signal has quiet passages where very little current is flowing. You can also check the Require Minimum Max Current Reading Of box and enter a value. In the example above, the system will check once every 2 minutes to verify that at least a 0.2 Amp reading was taken. If the Power Ramp feature is turned on (on the Power tab), the Upper Current Limit (assuming the initial wait period (30min above) has passed) will automatically be increased proportionally to the power increase.

4.6 Voltage Monitor Tab. The next tab is the Voltage Mon. Tab as shown here.



The DUT Status monitor will show the voltage being monitored. The voltage is measured at LifeTest back panel unless the 4-Wire option is employed. In that case, the voltage is monitored at the DUT via a second set of voltage sense wires (see the Hardware Setup in section 2.2) The voltmeter time constant is set to determine the amount of smoothing in the readings (this does not affect the sample size for each individual reading – that is set by the Rec Length drop down box in the Test Signal setup.) If the Save Voltage Data box is selected (this is the default case), the voltage data is saved and can be later recalled along with the measured current. This record can serve to validate the conditions of the test.

The Enable Voltage Correction box can be checked if the amplifiers being used have voltage outputs that vary with load impedance. LifeTest will modify the amplifier input level (audio device output level) to bring the measured voltage to within 2% or better of the expected value. A correction up to 15% is allowed (more than this probably means there is a problem with the amp.) The user can choose to shut down the channel if the required correction exceeds the Maximum Voltage Correction. The Voltage Correction feature should not be used to compensate for amplifiers that are being over driven (exceeding current or voltage output capability.) Doing so will modify the signal characteristics (crest factor and spectrum/distortion) and may very well result in damage to the amplifier.

4.7 Data Reduction Tab. The next tab is the Data Reduction tab as shown here.

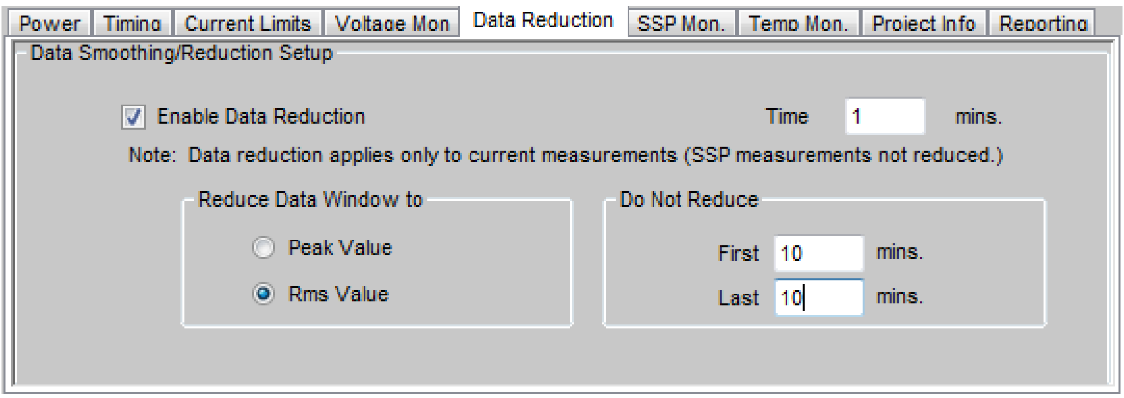
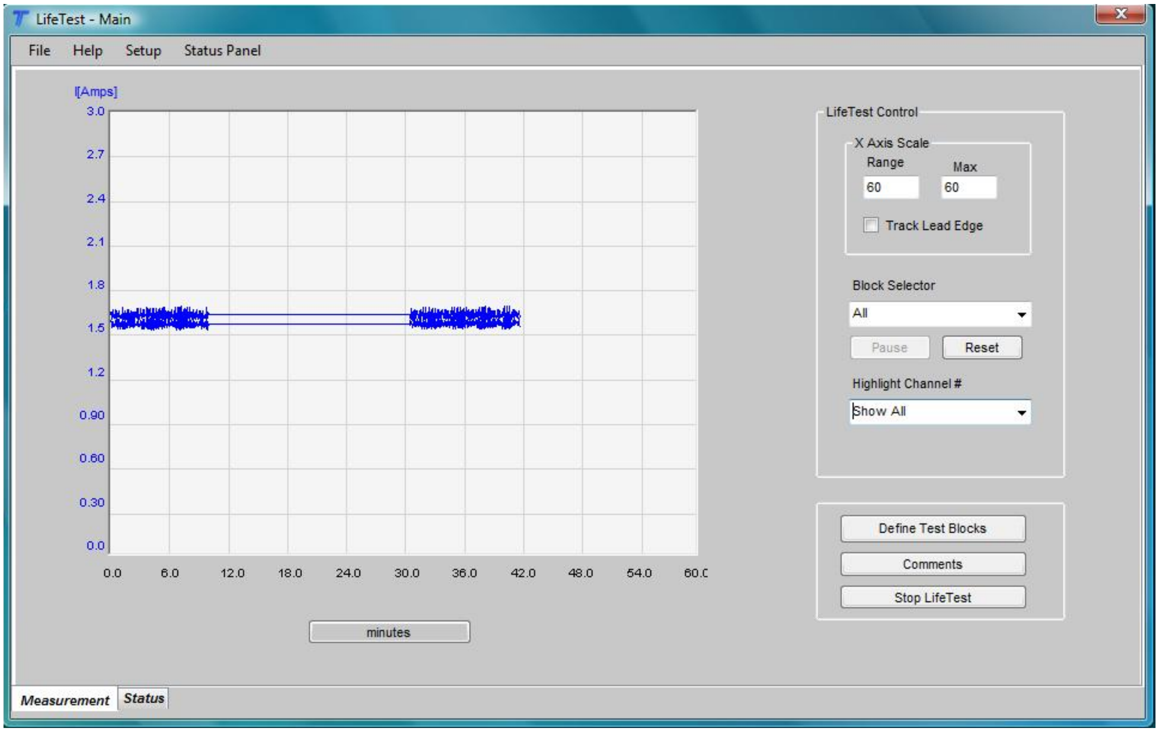
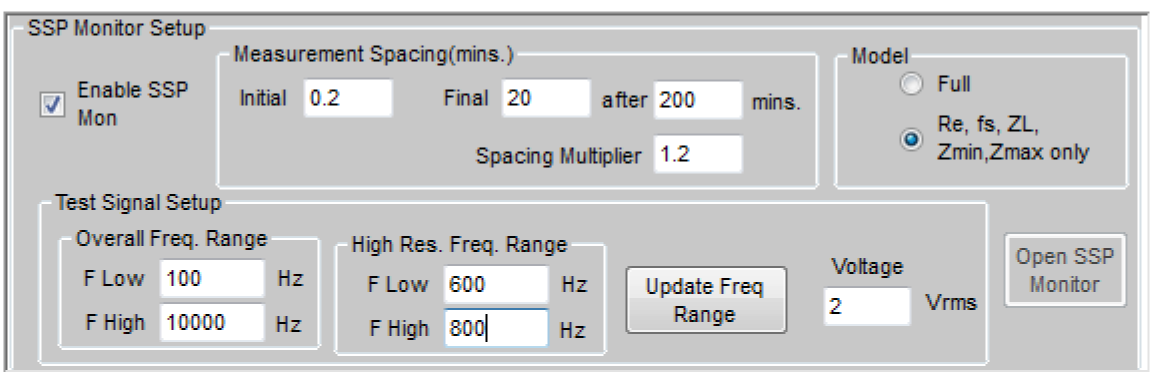


Figure 9. Data Reduction Tab in Block Setup.

When long tests with many channels are run, the amount of data collected can be enormous. Generating one data point every few seconds for 24 channels over a week's time can result in files that are hundreds of megabytes in size. They can be slow to work with. A good solution is the reduce the data on a scheduled basis. By checking the Enable Data Reduction box, the system will take either the Peak or Rms value calculated over the set time window and replace all the data in the window with a single point with it. If it is desired to not reduce the initial data (perhaps to see most dominant heating or suspension break-in effects), then enter a value in the box provided. Similarly, the last data points can be preserved. The latter feature is useful when a failure is noted. The data leading up to the failure is not wiped out with averaging or using the peak. For a week long test, values of 1 hour are typical for all 3 windows. This will reduce the dataset down to as little as 0.1%. Note: the Data Reduction feature cannot be used simultaneously with the Duty Cycling or Power Ramping features. Averaging data over on/off regions or different power levels would make for a confusing data set. Below is an example of two channels that have been data reduced to the rms average every 2 minutes with first and last10 minutes of the test preserved.



4.8 SSP Monitor Tab. The next tab is used to setup the SSP (Small Signal Parameter) Monitor as shown in below



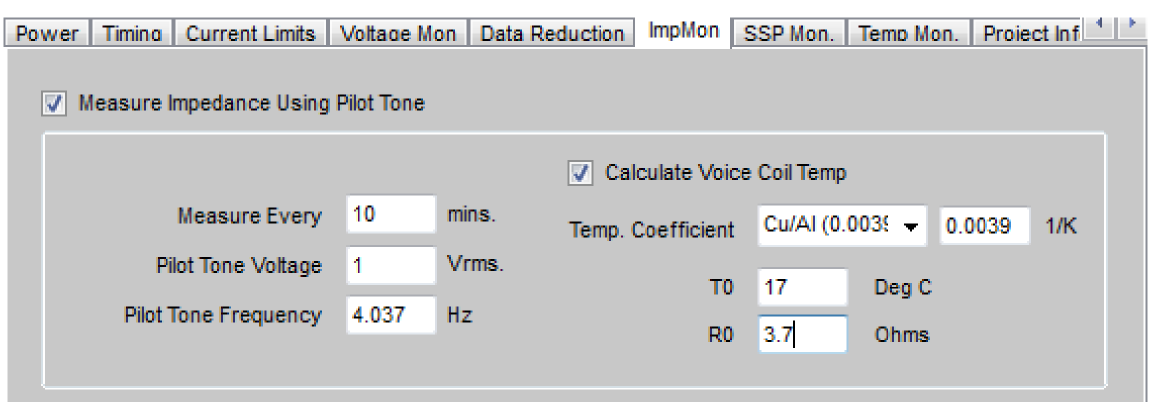
The system is capable of measuring SSPs for a DUT at scheduled time intervals. The SSP measurement works by playing a short (0.37secs) using a pink weighted 1/3rd octave spaced multitone signal over the frequency range set with F Low/F High and with the voltage specified. Additional tones can be added to the signal with 1/6th octave spacing using the High Res. Freq. Range Flow/FHigh text boxes provided. The system immediately returns to the block test signal so there is minimal interruption of the test. Measurements are made at intervals as set in the Measurement Spacing box. If the Final text box is left empty (or zero is entered) the measurements are made according to the

Initial spacing value. If a positive Final value is entered then the After and Spacing Multipliers must also be entered. In the above example, SSPs are measured starting at 0.2 minute intervals that increase by 20% (0.24, 0.29, 0.35…) until 200 minutes at which time the spacing is constant at 20 minutes. This allows a closer look at what happens as the DUT is heating to equilibrium (and the suspension softening if measuring a speaker.) The exact timing will depend on how many channels are being measured, etc. Care should be taken not to use too fine a spacing such that the SSP signal becomes a significant percentage of the test time. DUT cooling takes place during the SSP measurement and this may be an issue for some DUTs. Typically, a finer spacing will be used during a shorter preliminary test, often during the DUT development, to gain an understanding of the DUTs start up profile. Then longer reliability tests can be made with longer intervals, perhaps an hour, that provide an insight as to when/if a DUT starts changing beyond the expectation as may be the case at the onset of failure. The SSP algorithm uses a computationally intensive complex curve fitting algorithm and will slow down the system while it is active (maybe 1 second per channel per measurement.) This is another reason why it's probably a good idea to not use too short a measurement cycle. This is especially true if many channels are being measured. A fast processor (3GHz+/Dual Core or better) is recommended.

The SSP Monitor screen is opened when the button on this tab is clicked. The SSP Monitor allows manual measurement of the DUT to setup prior to running a test. See Appendix B. for more detail on how the SSP measurement works.

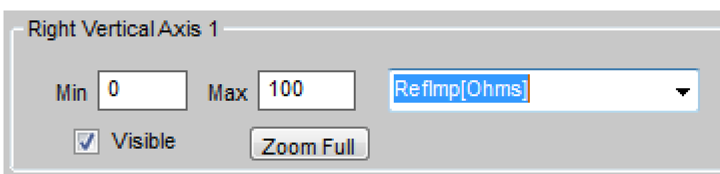
If a DUT is being tested that does not have a typical transducer impedance response (single motional back emf peak, inductive rise), the Fs, Re, ZL, Zmin, Zmax only option should be used. The DC resistance of a compression driver with extra peaks due to the throat or horn exit can be measured with this option. Loads without resonant peaks can be monitored this way as well.

4.9 ImpMon Tab. The graphic below shows the ImpMon or Impedance Monitor Tab. This feature allows you to setup the monitoring of a reference impedance using a test tone at a given frequency and a preset time interval.



If you wish to use this feature, check "Measure Impedance Using Pilot Tone box." Fill in the values for the period and test tone voltage and frequency. LifeTest will play the tone together with the test signal for one sampling cycle (setup in the Setup\General settings panel on the Main Screen.) It is recommended that the longest sampling window (1.49s seconds) be used for best accuracy. From the collected data, LifeTest will calculate the impedance value at the test frequency. The test tone voltage must be less than the test voltage entered on the Power tab. The accuracy of the extracted impedance value will depend on the main test signal used, the level of non-linearity of the DUT, and the frequency and level of the test tone. Better results are often achieved by using a tone outside the bandwidth of the test signal. If the amplifier used has a sufficiently low cutoff frequency, test tones as low as 2 Hz can be used to measure the impedance. This value will be very close to the DC resistance of a woofer even if it has a fairly low resonance frequency. If the main test signal is a pink noise signal high pass filtered above 20 Hz, usually this method will yield good values indicative of the DC resistance. Some experimentation may be required to get the most accurate and repeatable measurements. If the variation is still too high, a better method for extracting Re might be to use the SSP monitor (see section 4.8.)

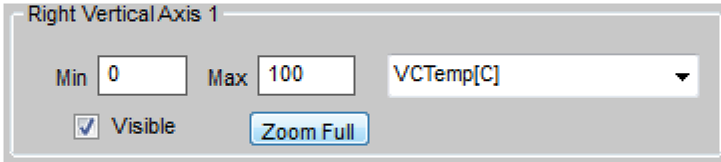
The reference impedance can be monitored on the Main Screen graph by selecting RefImp(Ohms) from the Graph Setup panel (right click on the Main Screen graph) for one of the two Right Vertical Axes.



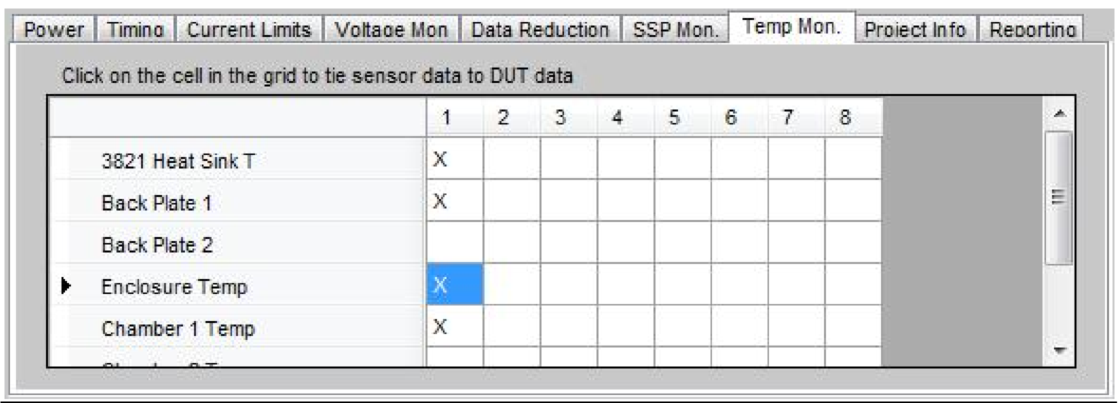
LifeTest can also use the reference impedance to calculate the voice coil temperature of the DUT. Check the box to engage this feature. The formula

$$T(t) = \frac{\frac{R(t)}{R(0)} - 1}{\alpha} + T(0)$$

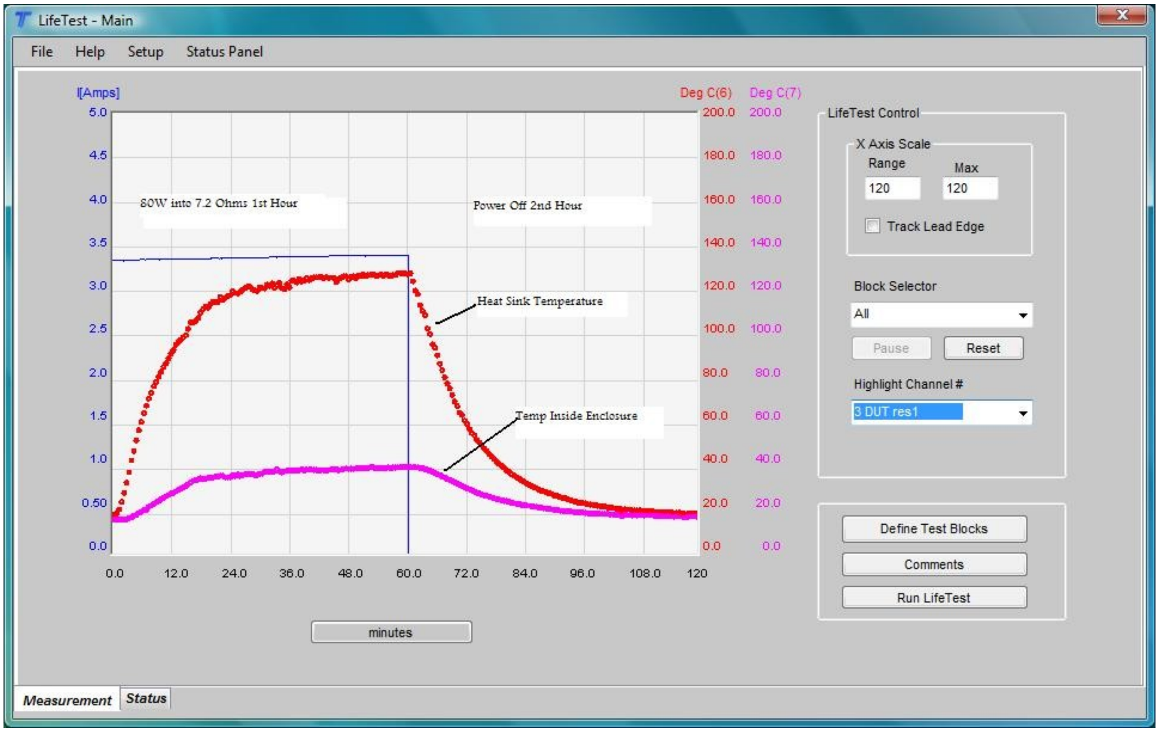
is used to calculate the Temperate at the sampling time t. The reference values for R(0) and T(0) are entered in the provided boxes. The temperature coefficient of resistivity α for the voice coil winding material is also entered. For copper and aluminum wire, the value is very close to 0.0039/K and can be selected from the drop down box or an alternative value can be entered directly. Similar to the RefImp plot, select the Voice Coil temp for one of the Right Vertical Axes on the Graph Setup panel to plot it to the Main Screen graph.



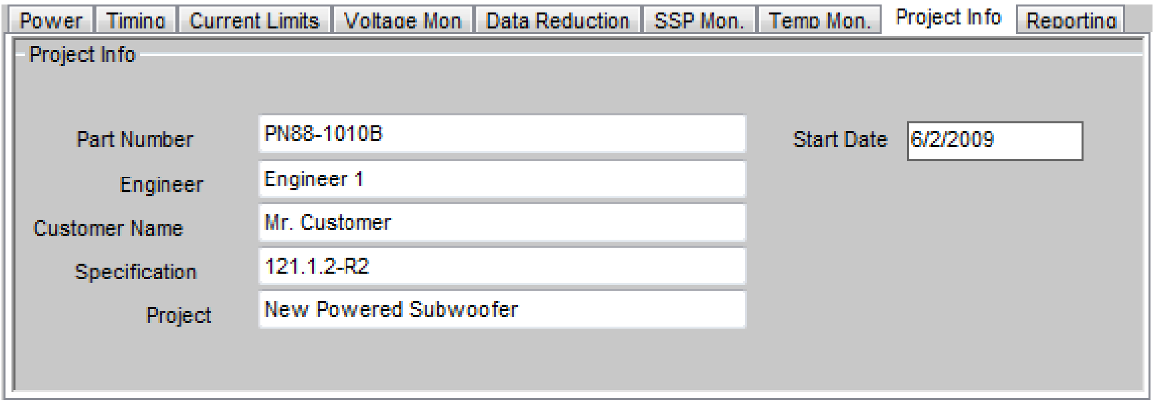
4.10 Temperature Monitor Tab. Any sensor activated in the sensor calibration screen (see section 2.6) can be tracked along with any DUT current monitoring channel. The sensor data is continually collected according to the interval set during calibration. Copies of the sensor readings can be stored alongside the current readings so the two datasets are always aligned in time. Select a sensor to track along with a DUT by clicking the grid where the DUT Channel (along the top) and the sensor of interest and an X will indicate the connection. Click the box again to remove the X. In this example, the data from the 4 selected sensors will be tracked with channel 1 using the same timing.



The graphic below shows two of the sensors selected for plotting alongside the current for a power amplifier being tested. In this case, the sensor reading interval is set to 0.5 minutes. One sensor tracks the heat sink temperature and another tracks the temperature inside the amplifier enclosure. The duty cycle feature is used to turn the power off after 1 hour and the temperature continues to track for a second hour. The other sensors tied to this channel can be selected for viewing as well and the data for all is saved with the current record.

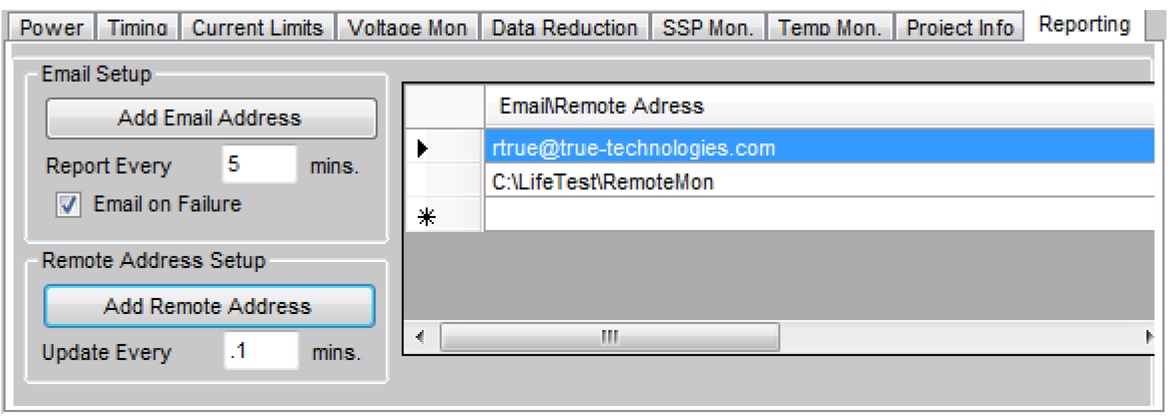

LifeTest - Main
File
Help
Setup
Status Panel
I[Amps]
Deg C(6)
Deg C(7)
80W into 7.2 Ohms 1st Hour
Power Off 2nd Hour
Heat Sink Temperature
Temp Inside Enclosure
minutes
LifeTest Control
X Axis Scale
Range
Max
120
120
Track Lead Edge
Block Selector
All
Pause
Reset
Highlight Channel #
3 DUT res1
Define Test Blocks
Comments
Run LifeTest
Measurement
Status

4.11 Project Info Tab. The graphic below shows the Project Info tab. The data entered here stays with the test results.



Project Info Tab in Block Setup.

4.12 Reporting Tab. The Reporting setup tab is shown below.



Reporting Tab in Block Setup.

The system can email reports showing DUT statics on a periodic basis. To enable this feature, add email addresses of the recipients to the grid by clicking the Add Email Address button and then enter the time interval to send reports (must be greater than zero.) The email information must be setup in the General Setup option from the Main Screen Setup menu. See General Setup in section 2.7 for more details. Below is an example of a typical report sent out by LifeTest.

```
This is a LifeTest Report from LT Station 1 BT Lab
5/7/2009 9:43:22 AM

Part Number: X21-3.1
Project: New Powered Subwoofer
Customer: N/A
Specification: SW-125W
Engineer: Mr. Mann
Test Signal: RS426B.wav
Test Duration: 2.0 hrs.
Power Profile: 1.0W (2.00Vrms)

Channel Status
  1) Time Left:115.7 mins Power:125W
  5) Time Left:115.7 mins Power:125W
  6) Time Left:115.7 mins Power:125W
  8) Time Left:115.7 mins Power:125W
```

It works well to setup a separate email account that all power test results are sent to. A readily accessible history is maintained that can be searched by engineer, customer, part number, etc. by using the email database search tools.

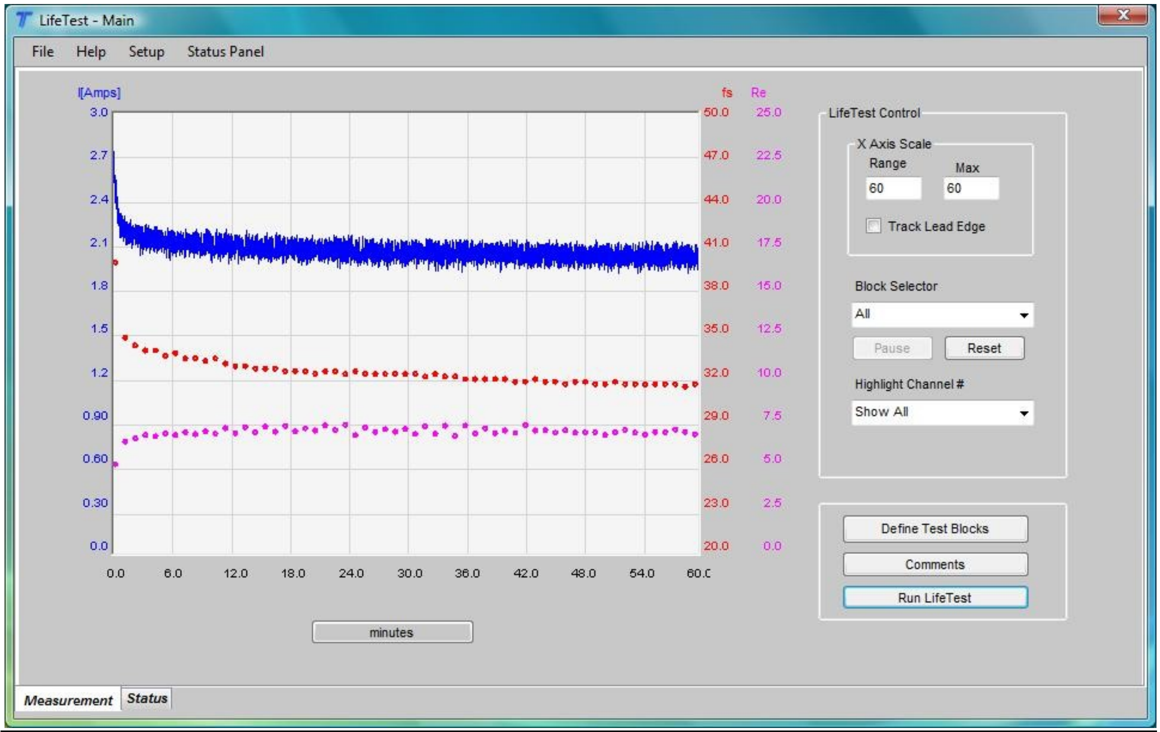
LifeTest also comes with a Remote Monitoring Tool that can be used to monitor the channel status in near-real time. Enter the directory to write results to by clicking the Add Remote Address button and set the time interval for writing the file. The Update Every period must be greater than zero. Make sure the system has write access and the monitoring party has read access to the directory. With a VPN connection and the LifeTest Monitor, up to the minute test status for products testing on the opposite side of the world is possible. See Appendix C. for more info on the LifeTest Remote Monitor.

5.0 Running A Test

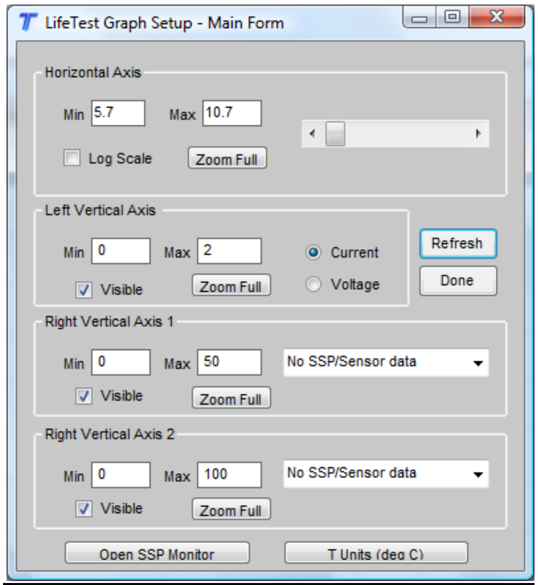
Once the block is setup and saved, go back to the Main Screen and click Run Power Test to start the measurement. The selected data (discussed below) will begin to plot across the screen with time. The screen below shows the data for a single channel with the current plotted against the left axis and two of the available SSPs (fs and Re) plotted against the different scales on the right axis.

When multiple channels and multiple blocks are running simultaneously, the data tends to pile up and can be confusing to sort through. A single block can be viewed by selecting it in the Block Selector drop down box. To further filter to a single channel, choose the channel #/DUT name in the Highlight Channel # drop down.

The X Axis Scale can be set in one of two ways. First, the Max value and Range can be entered into the boxes provided. As shown, the system will plot the 11 minutes of data ending at 10 minutes. If the Track Lead Edge box is checked, the Max value will automatically update as the leading curve in the highlighted block (or all blocks if ALL is selected) crawls past the right edge of the graph. The range is maintained and the plot shifts halfway back so the data starts crawling again from the middle of the graph.



A single channel being tested with current, fs, and dc resistance plotted



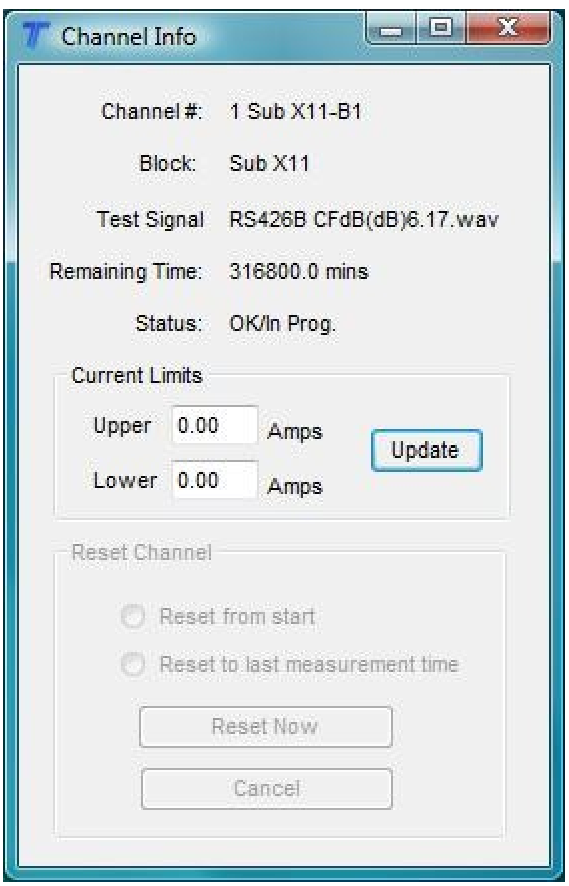
By selecting the Graph Setup from the Setup menu on the main screen this screen will pop up. It can also be brought up by just clicking on the graph. The horizontal axis can be also set by entering limits or by clicking zoom full so the time limits (0 to t max) for the block currently selected will be filled in. The scroll bar allows the user to move laterally through time while inspecting chunks of the data. As mentioned previously, the left vertical axis is always used for plotting the measured current or voltage values. The values for the Right Vertical Axis1 and Right Vertical Axis 2 are selected from the drop down boxes provided that contains a list of the measured SSPs if the SSP Monitor is enabled. Any vertical axis can also be zoomed to full where the peak value is searched out from the plotted curves and the scale is set to the peak plus 10%.

When monitoring temperature or humidity, the desired sensor values can also be selected in the drop down boxes for plotting against either Right Vertical Axis. Temperature units can be toggled between Fahrenheit and Celsius by clicking the button. The SSP monitor can also be opened from this screen.

Back to the main screen, the horizontal axis label is a button that can be clicked to toggle between minutes and hours. Notes on DUTs, test observations, etc., can also be readily viewed and edited by clicking on the comments button – see section 4.1 for more details.

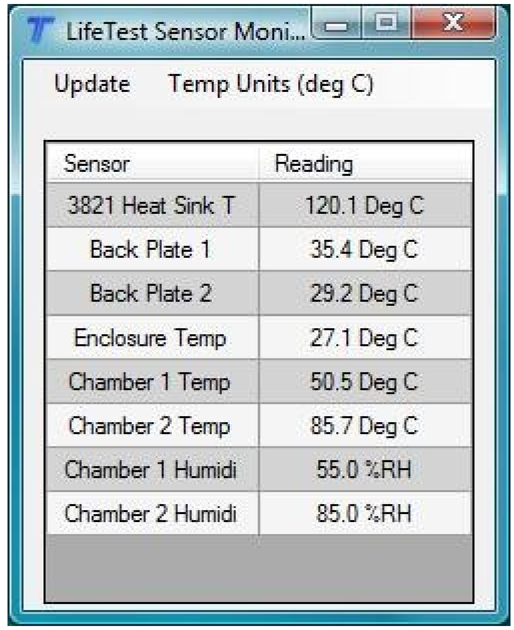
6.0 Monitoring Tests In Progress

Click on the Status Monitor menu option from the Main Screen menu to see this screen. Every active channel will be summarized with pertinent information. The buttons across the bottom row show the color coded status.
Green indicates the DUT is OK and running, or that the test finished successfully. Yellow indicates the test was paused manually or that it is currently in the Duty Off phase in a duty cycling test. Red indicates the channel was shut down and the button text will give a status code.



Clicking on a status button will pull up a Channel Info screen as shown here. The channel # is indicated along with additional setup information and the current status. If the channel has been shut down, an opportunity to reset the channel either by starting from time t=0 or from the last recorded measurement time (just when it was shut down.) The former option is typically used when a DUT has been inspected and confirmed to fail and a replacement DUT is added to the block. However, when this option is selected, all the previous data taken is lost permanently.
The Reset to last measurement time option is used if the DUT is inspected and no problem is found. In this case, the system keeps track of the timing relative to the other devices in the block. For example, if an hour was lost due to shut down, the other DUTs in the block will finish according to the test duration and the restarted device will finish one hour later. If it appears that the shut down was caused by one of the current limits being too tight, the limits can be updated on this screen. Type in the new values in the boxes provided and hit update. This is the only parameter that can be changed after a test block has been started.

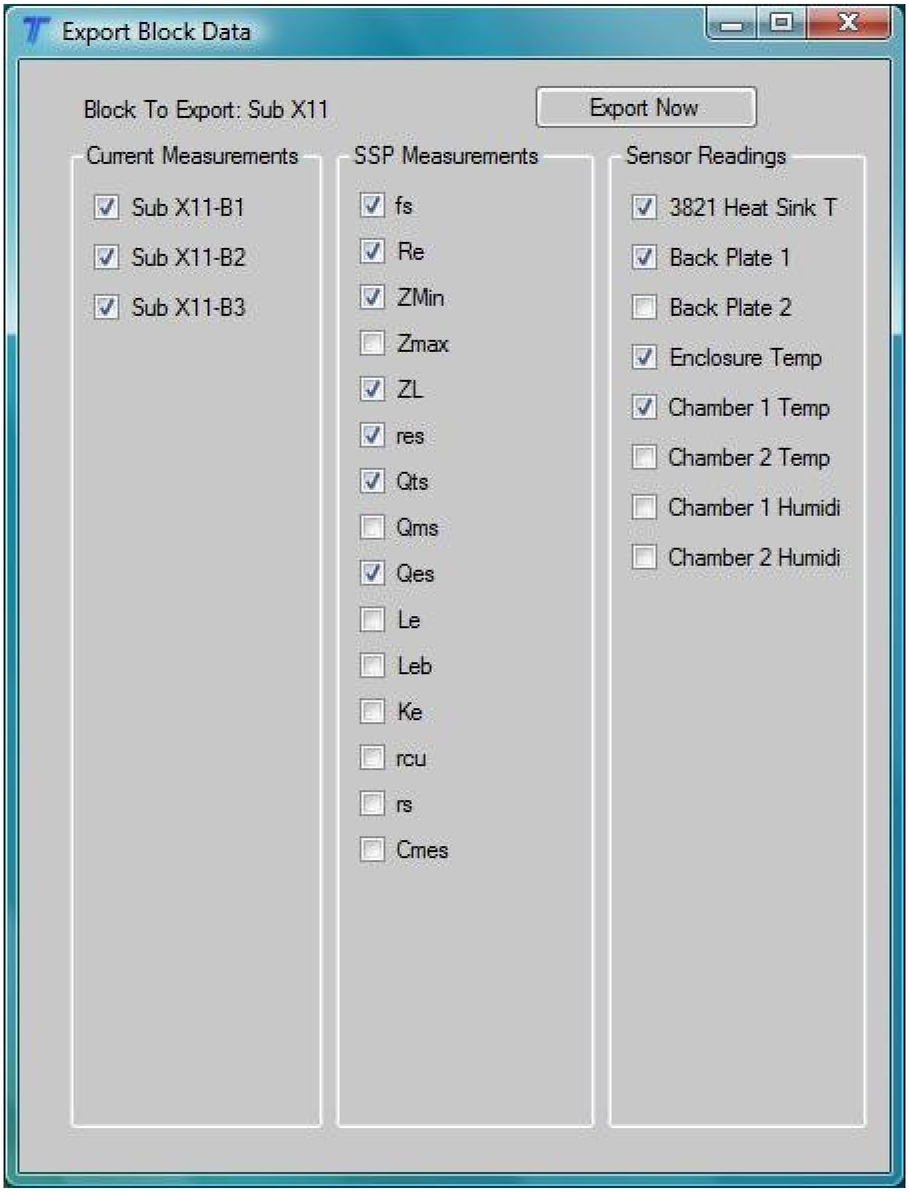
Temperature and humidity sensor readings can also be monitored by opening this window from the Status Menu option. Only sensors activated on the calibration screen (see section 2.6) will be shown. Temperature units can be toggled between Celsius and Fahrenheit by clicking on the menu option.



7.0 Exporting and Archiving Data

When a test block is completed or for some other reason is no longer needed, open the Block Setup by clicking Define Test Blocks button. Select the block and click the Remove button. The software will ask if the data should be archived. Doing so allows for future recall of the block. If the data is not archived, it will be lost forever. From the Main Screen File menu option the View Archived Data option is used to retrieve the archived block. This can only be done while no test is running. Data collected for current test blocks is saved and the archived data is presented. When archived data is loaded into memory, the Main Screen File menu will have a Restore Current Block option. This clears the archived data and restores the current block(s) and testing can resume.

The data can also be exported. Select the block you want to export from the Block Selector drop down on the Main Screen. Click the File\Export Block menu option and the screen below is presented. All channels in the block and any SSPs or Sensor data can be selected by checking the boxes. Click the Export Now button and provide a file name to export to. The data is saved in a .csv (comma separated values) file that can be opened in Excel or any text editor.



8.0 When AC Power Goes Out

If the host PC is setup to automatically reboot and start the LifeTest software, the system will pick up where it left off if the power went out during a test. The timing of the test is maintained. If the email reporting feature is activated (see section 4.10), a message is emailed indicating the time the power went out and that the system has restarted itself.

9.0 Running in Viewer/Demo Mode

If the software is started without a LifeTest box installed or if the box has not been activated, it will run in Viewer/Demo mode. LifeTest will work like it normally does except the I/O functions are not enabled and data is fabricated to simulate running a test. If a second instance of the software is started while the system is running a test, it will also run in Viewer/Demo mode. This allows for the viewing and exporting of archived data without the need to interrupt the test in progress.

10.0 Troubleshooting

In the event of trouble with the system, check these things first:

- Make sure all signal cables from the LT box to the audio interface are connected, even if you are only measuring less than the full number of channels. The current/voltage inputs are shared among channels and are not in a 1-1 arrangement
- If communications to the LT box is lost (or if you have strange behavior and you're not sure what is wrong), exit the software and unplug the USB cable from the LT box. Wait a few seconds, plug in the USB cable and restart the software. The license info box should indicate the presence of the LT box and how many channels are available. Communications can be lost when the hardware setup is changed, including when cables are connected/disconnected. Hardware changes should only be made when the power to all devices is off.
- If channels 5-8 do not appear to be measuring correctly, check the previous note on lost communications. It may be that the relays in the LT box are not opening/closing and the signals are not being routed properly.
- If the current measurement does not seem to be correct, consider the impedance response of the DUT. A coil with a DC resistance of 4 Ohms may measure with a much higher impedance/lower current due to back emf near a loudspeaker's resonance, rising inductance, etc.

Appendix A. Using the Signal Generator Module (SGM).

The Signal Generator Module can be used to create a wide variety of test signals. To start the Signal Maker, select the option from the Main Screen Setup Menu. Click Help from the newly opened screen for information on the module.

Appendix B. Using the SSP Measurement Feature.

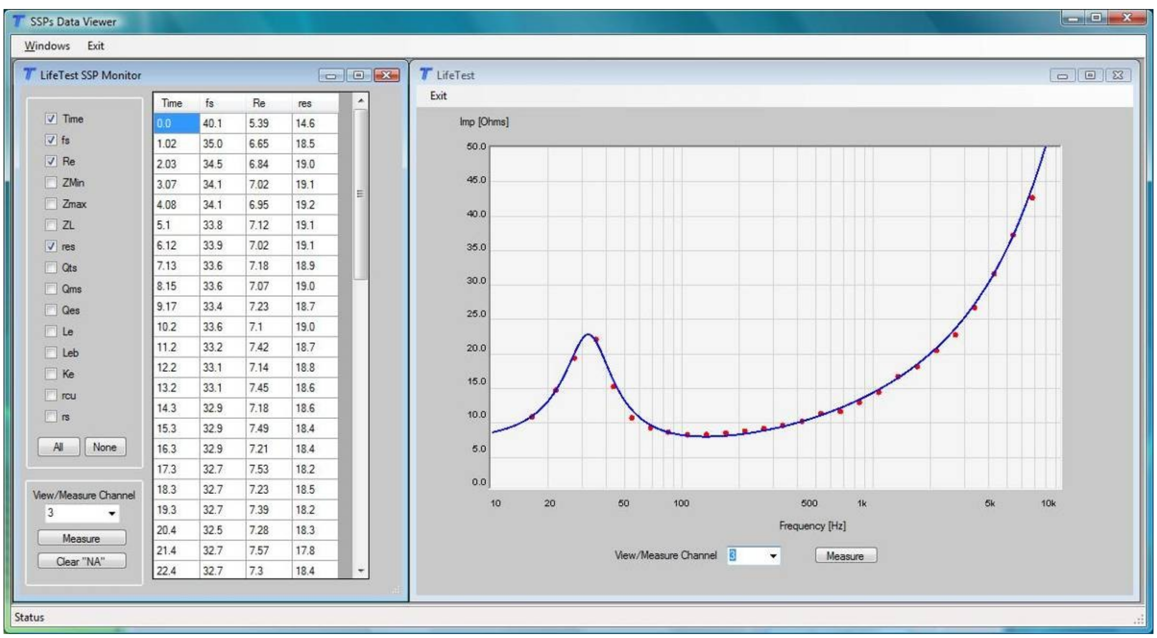
The SSP algorithm uses a multitone signal with tones space at 1/3rd octave intervals between the start and stop frequencies set on the SSP Mon. tab in the Block Setup screen. Additional tones can be added with 1/6th octave spacing between the frequencies entered in the High Res high and low frequencies. The measured current values at each tone frequency are extracted from the recording and then equalized for the system response and signal spectrum. A complex curve fitting algorithm is applied to extract the parameters of the model developed by Knud Thorborg and Andy Unruh as discussed in a paper in the JAES[1]. Each of the parameters is selectable for viewing from the Graph Setup screen for either of the two right vertical axes.

The signal uses a pink weighting so there is more energy at lower frequencies where a resonance impedance peak is likely to be. At these frequencies the actual current flow is quite small so a higher relative voltage in the region helps with signal-to-noise ratios to get cleaner measurements.

The multitone signal is used because all frequencies can be played simultaneously and the interruption to the power test is shorter than it would be if a full sine sweep was made. The multitone only requires 0.37 seconds to play and the power test signal is resumed before the calculations to fit the model begin. The energy in the multitone signal is also concentrated at all frequencies used for the duration of the test so the signal-to-noise ratio is better than a fast sweep or other signal types (e.g. MLS.)

The LifeTest system is optimized for a current dynamic range to accept peak levels of 120 amps (30 amps continuous with a 12dB crest factor.) As such, measuring in the milliamp range is very difficult to do, especially in a very short time period. The situation is even more challenging when the measurement is done while several other transducers being tested in the general vicinity are generating huge levels of sound pressure (the transducer diaphragm is acting like a microphone and the back emf generated by external sound waves can show up in the impedance response.) As such, it is recommended that a voltage level be used for the SSP multitone signal that allows at least 50 milliamps to flow. This is quite a bit more than the few milliamps typically used with traditional SSP measurements and as such the measured values may be somewhat different than those measured in a typical lab setup. However, the measurements are still meaningful and consistent enough to draw good conclusions about the DUT changes that occur during testing. Care should also be taken to not use too high a voltage so that the transducer is driven into significant non-linearity causing the current measurements to be significantly distorted to the point it affects the accuracy and repeatability of the resulting data. For an 8 Ohm transducer, a 2 volt setting usually works well, but some experimentation will likely be needed to get good results.

Below is a plot of the measured current at the multitone frequencies (after system and signal compensation.) The model usually fits the data pretty well. One of the useful aspects of this model is the estimation of the DC resistance, Re. The change in Re from the baseline measurement can be used along with knowledge of the ambient temperature to get a good estimation of the voice coil temperature. It is recommended that the test be allowed to run long enough to let the Re value stabilize about some final value and then take the average of several of the final readings to use in the temperature calculation. The values of the parameters (at least those not so small that they are buried in the noise) can vary by 5% or more depending on the nonlinear behavior of the driver, the acoustic surroundings, etc. Even with lab equipment, some key SSPs can vary by this much in gage R&R studies.

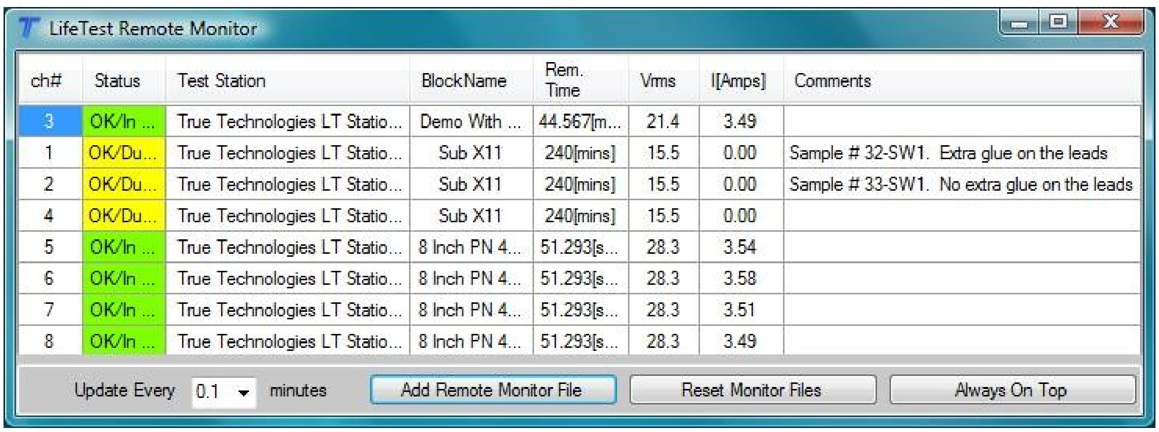


The left window shows the SSPs that are selected from the check boxes. Each row contains a time stamped (minutes from the beginning of the test) set of parameters. The channel to be viewed must first be selected in either window (the other window will update to be the same.) When a test is not running, the Measure button will take a measurement and the results are shown. This can be useful when setting up the measurement before running a test. The setup parameters are set from the Block Setup SSP Monitor tab. The Block must be saved before the test can be run from this screen.

1) **Electrical Equivalent Circuit Model for Dynamic Moving-Coil Transducers Incorporating a Semi-Inductor.** Thorborg, Knud; Unruh, Andrew D. **JAES Volume 56 Issue 9 pp. 696-709; September 2008**

Appendix C. Using the Remote Monitor Feature.

To use the LifeTest Remote Monitor, install the software application on the PC where you want to monitor the test progress by running setup.exe in the Remote Monitor directory of the LifeTest installation package. The Remote Monitor software may be freely distributed to anyone needing to monitor the status of a purchased LifeTest system. Start the monitor using the shortcut on the desktop or in the startup menu.



To start the monitoring process, first set the update time. Then click on the Set Remote Monitor File button and browse to find a .rmf file for monitoring. The user account must have Read (at least) access to the directory. The .rmf file is created by the LifeTest software and represents a single test block. Up to 100 different .rmf files can be selected so monitoring can be done on multiple blocks and multiple test stations in various locations all with the same screen.

Once the .rmf file is selected, the Monitor will begin opening the file at the selected intervals. The status, time remaining, and other information is available. The status cell in the grid is color coded according to the state the DUT is in. The cell will turn grey if the Monitor cannot access the file for any reason.

The Always On Top button can be clicked to keep the application in full view on the desktop while the user goes about other business on the PC. If Always On Top is not enabled, the application will jump to the front if a channel that is being monitored changes to show a failure.

Appendix D. LifeTest Specifications and Minimum Requirements

LifeTest Hardware Single Channel Maximum Ratings*

Continuous current	30 amps rms
Peak Current	120 amps
Continuous voltage	100 volts rms
Peak Voltage	400 volts

* Inquire with True Technologies if these ratings need to be exceeded
Note: Devices where less than 50-100mAmps of current flow may result in noisy measurements. Inquire with True Technologies if this is a possibility.
When measuring SSPs below 100 Hz, it's best to use signals that deliver 150mAmps of current or more. See the section on measuring SSPs.

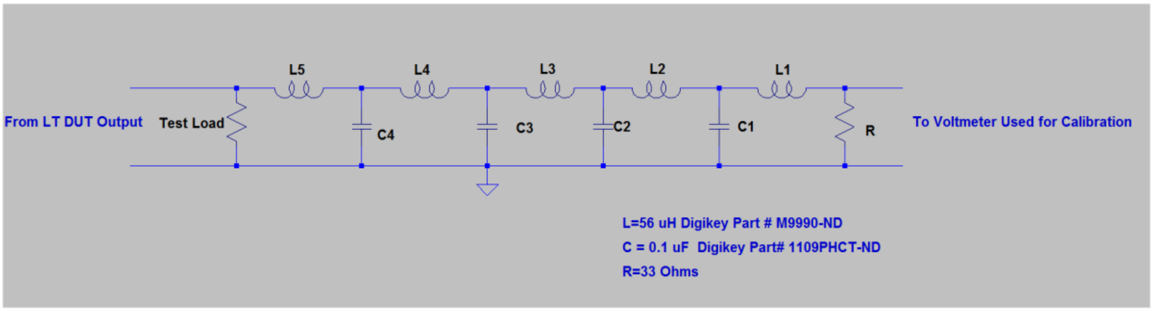
Computer Requirements

Operating System	Windows XP or higher
Processor	Dual Core/2.0 GHz or faster
Ram	4 gbytes or more
Hard Disk	100 gbytes or more
Bus	USB 2.0

Audio Device – Windows compatible with 1 available channel of analog input and 1 available channel of analog output for each LifeTest channel. WDM or Windows Legacy Device drivers required. Echo Audio AudioFire 12 is recommended and shipped with most LT systems.

Appendix E. Using LifeTest with Switching Amplifiers

Most switching amplifiers have some remnants of the PWM switching signal after the output filter. The LifeTest audio devices record and measure the current and voltage signals using a 44.1kHz sampling rate and associated anti-aliasing filter. Hence, the switching ripple is filtered off and not captured in LifeTest measurements. However, most voltmeters will have a much larger bandwidth and the ripple voltage will be included in the calibration readings and will lead to calibration errors that can be significant. Much better accuracy will be attained if a low pass filter is inserted between the test load and the voltmeter used during the calibration routine. A schematic for an inexpensive filter is shown below. This circuit has a steep roll off above 150kHz and mostly a flat response in the audio band. The filter is not needed during testing – be sure to remove it as testing at high power will destroy the components.



Low Pass Filter for Calibrating When Using Switching Amplifiers.