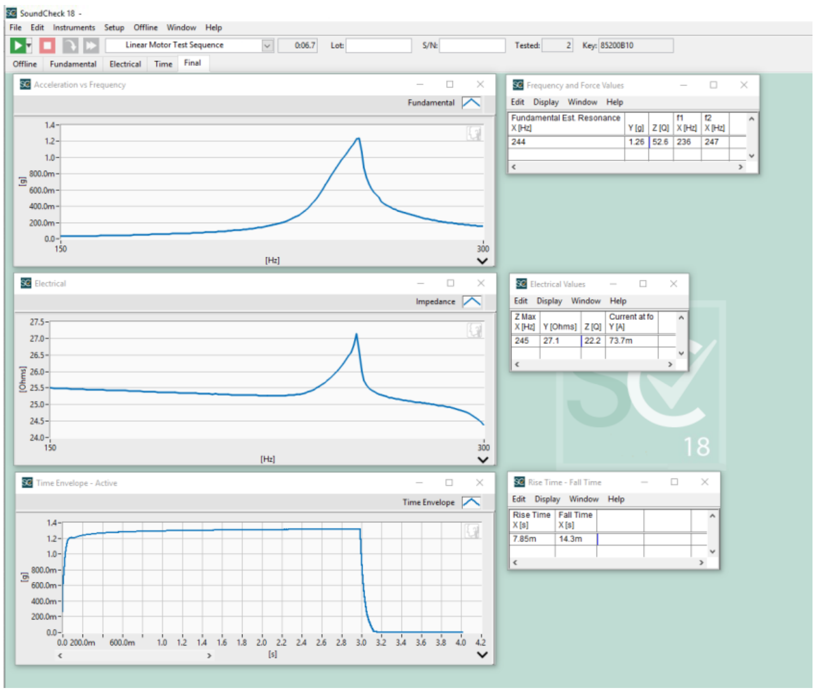
Linear Motor Test Sequence

Introduction

Linear motors (also known as linear vibrators or linear resonant actuators) have become increasingly popular in handheld devices such as phones and tablets for providing haptic feedback to the device's user. The typical linear motor design uses a fixed voice coil in conjunction with a moving magnetic mass. A spring is placed between the mass and the motor's housing to provide compliance to the moving system.

The design goal of linear motor is to create a "High-Q" system so that the device has a very strong resonant frequency across a narrow frequency bandwidth. The motor is then operated at its resonant frequency to produce maximum output (vibration) while having minimal power demands on the portable device. The strength of the vibration is controlled by adjusting the magnitude of the AC signal input to the motor.

The purpose of this sequence is to measure the important performance characteristics of a linear motor. Since we are measuring vibration, an accelerometer must be used. The sequence begins by exciting the motor with a sine sweep. Since the operating frequency range of a linear motor is typically 200 Hz ±20%, the sweep range is limited to 150Hz-300Hz. An analysis step calculates the fundamental output of the accelerometer and post processing steps calculate f_0 (resonance frequency) and the f1 and f2 (-3dB) values. A second analysis step calculates the electrical impedance of the motor while subsequent steps calculate the electrical f0, Q and current at f_0. Lastly, the motor is excited with a single tone at f_0 and a Time Envelope of the recorded time waveform is used to calculate the motor's Rise Time and Fall Time values.



Final Display for *Impedance* Using Math Post-Processing sequence

Software Requirements

SoundCheck 18 Basic or later

Hardware Requirements

Audio Interface – Listen AmpConnect or similar

Accelerometer (IEPE bias) – Brüel & Kjaer Type 4519-003 or similar

Test Jig (typical: material=Delrin, dimensions = 105mm x 15mm x 10mm, weight=100g)

Polyurethane foam pad

Hardware Setup & Calibration

Note: This test sequence is designed for use with Listen's AmpConnect hardware. With some minor modifications (e.g removal of the AmpConnect Message Step), it can be adapted for use with discrete hardware components.

1. Connect the accelerometer to the AmpConnect Reference input and enable the inputs's IEPE bias
2. Calibrate the accelerometer. There are two options:

a. If you know the accelerometer's sensitivity and reference frequency, you can enter these values directly into the appropriate fields in the Accelerometer's calibration field in System Calibration. When you imported the Accelerometer calibrated device file to your system, it should have pre-configured your calibration with the proper units of force (V/g)

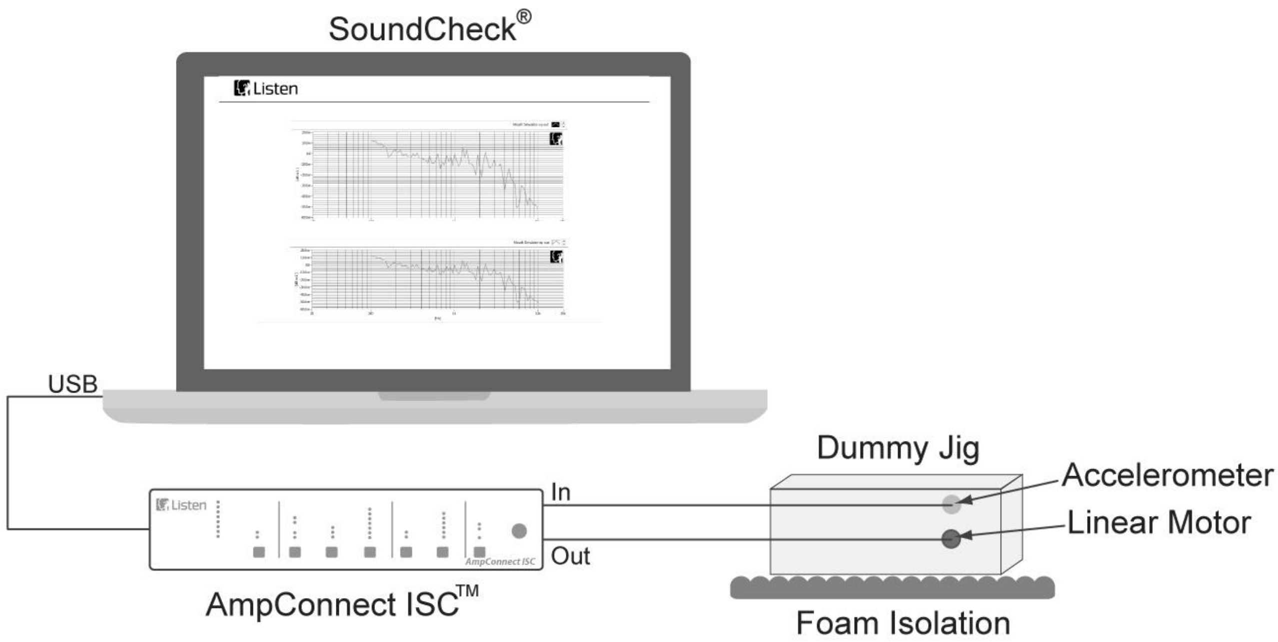
b. You can also calibrate your accelerometer using SoundCheck. Choose "Accelerometer Calibration" in the Calibration Sequence drop-down and attach the accelerometer to an accelerometer calibrator such as the B&K Type 4294. Click the Calibrate Device button. This performs a simple Voltmeter reading while the accelerometer is being excited by the calibrator at the reference level. Click OK in the Voltmeter to accept the measurement. You'll see the sensitivity automatically update in the Sensitivity field.

3. Connect the linear motor to AmpConnect Output A
4. Mount the linear motor and the accelerometer to the test jig as shown in the following System Diagram
5. Place the test jig onto the foam pad

   You are now ready to start the sequence

Listen

System diagram



Sequence Logic

Type	Step Name	#	Out	In	
Mes	Recall Data	1			
Rec	Recall curves	2			// Recalls example curves and values
Rec	Recall waveforms	3			// Recalls example waveforms
Mes	AmpConnect	4			// Configures AmpConnect for test sequence
Mes	Enter Test Level	5			
Sti	Stweep - 300Hz-150Hz	6	Amp ch 1		
Acq	Play & Record	7	Amp ch 1	Impedance Box Accelerometer	
Ana	Fundamental	8			
Ana	Impedance	9			
Pos	Est. Resonance 1	10			// Post-process of impedance curve to calculate fo
Pos	Est. Resonance 2	11			// Post-process of accelerometer curve to calculate fo
Pos	Curve minus constant dB	12			// Calculates the -3dB value for f1 and f2
Pos	Intersection 1	13			// Search and return f1

Pos	Intersection 2	14			// Search and return f2
Pos	Curve divided by constant	15			// Current @ fo
Dis	Fundamental	16			
Dis	Electrical	17			
Sti	Single Tone	18	Amp ch 1		// Creates a single tone stimulus at fo
Acq	Play & Record	19	Amp ch 1	Accelerometer	
Ana	Broadband RMS	20			// Calculates the Time Envelope of the filtered waveform
Pos	Maximum	21			// Calculates the maximum value of the Time Envelope
Pos	Curve divided by constant	22			// Divides the Time Envelope maximum by 2 (for rise time and fall time calculation)
Pos	Intersection	23			// Calculates Fall Time Intersection point
Pos	Curve minus constant	24			// Calculates Fall Time
Pos	Intersection	25			// Calculates Rise Time
Dis	Time	26			
Dis	Final	27			

Further sequence development

Ways in which you could modify or further develop this sequence include:

- Add autosave steps to store your data and results
- Test for loose particles
- Incorporate the impedance test into a larger suite of tests similar to the *Complete Test* sequence