Producing a Clean Sine Wave to Better Drive Speakers

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Introduction

At low Reynolds numbers flow can be easily disturbed, ultimately creating a potential for devices like speakers to affect and control airflow. By creating such disturbances using speakers, one can manipulate where a laminar separation bubble forms and thus improve the efficiency of an aircraft. However, before these benefits are realized, the ways in which sound affects airflow have to be further investigated.

Objective & Impact

- We aim to experimentally explore and address issues with our acoustic system.
- By addressing issues in the current acoustic system, we are preparing to further investigate the effects of sound on airflow, ultimately creating a potential for the improvement of aerodynamic properties of small scale aircraft.

Methods

While the eventual goal is to use an array of eight speakers and pressure transducers to influence flow and investigate potential aerodynamic improvements, we first had to fix issues with the acoustic system. To do this, we used a Speedgoat real time target machine.

We created a Simulink model and incrementally tested and modified it to identify and address issues in the acoustic system. We used an oscilloscope to compare measured and expected outputs, ultimately allowing us to identify the issues of positive voltage restriction, low output rates, and the exceeding of the maximum amplitude for the speakers.

Debugging Process

Challenges:

Asymmetric Sine Wave:

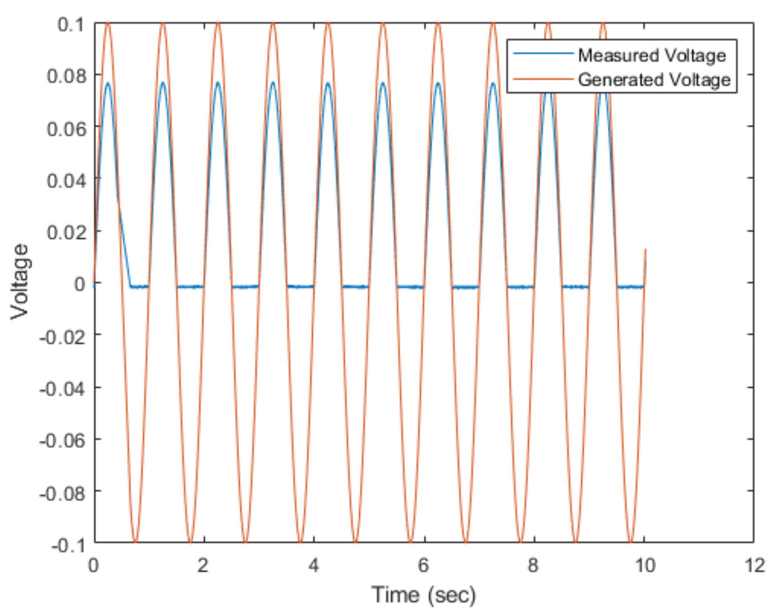
Originally, when observed with an oscilloscope without the speaker attached, the wave only produced positive voltage and had a very choppy shape. By observing with an oscilloscope that the voltage was never negative, we were able to find that the asymmetric nature of the wave resulted from a limitation in the settings of the Speedgoat that limited outputs to positive voltages.

Low Detail Waveform:

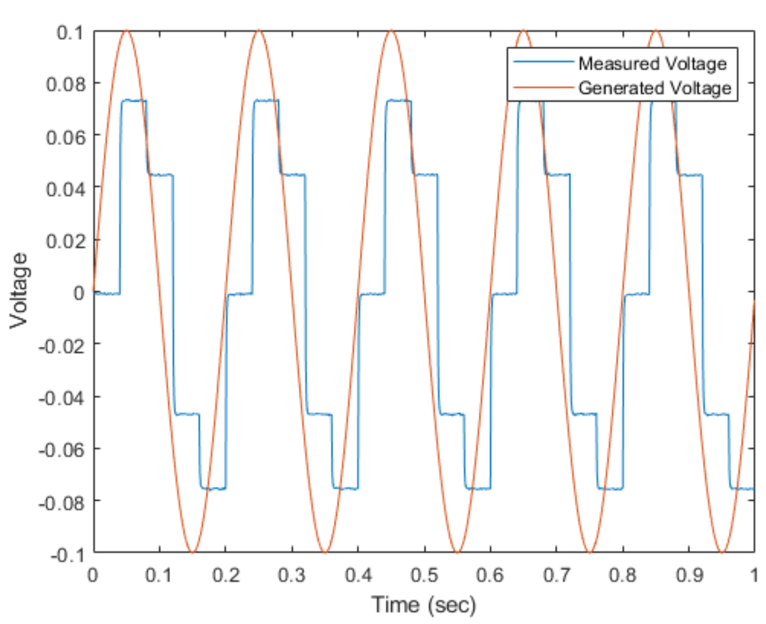
The waveform outputted from the Speedgoat originally had a very staggered appearance. We were able to reveal the reason for this by measuring the waveform at different target frequencies. As the low frequency sine waves looked the smoothest, we could infer that the refresh rate for the output was too low. We were able to fix this in the Speedgoat settings. However, this problem still persisted at high frequencies after we changed the settings. Despite the speakers' maximum rated frequency of 7.4kHz, we could only run them at a maximum frequency of 1kHz due to the loss of detail.

Plateauing Waveform:

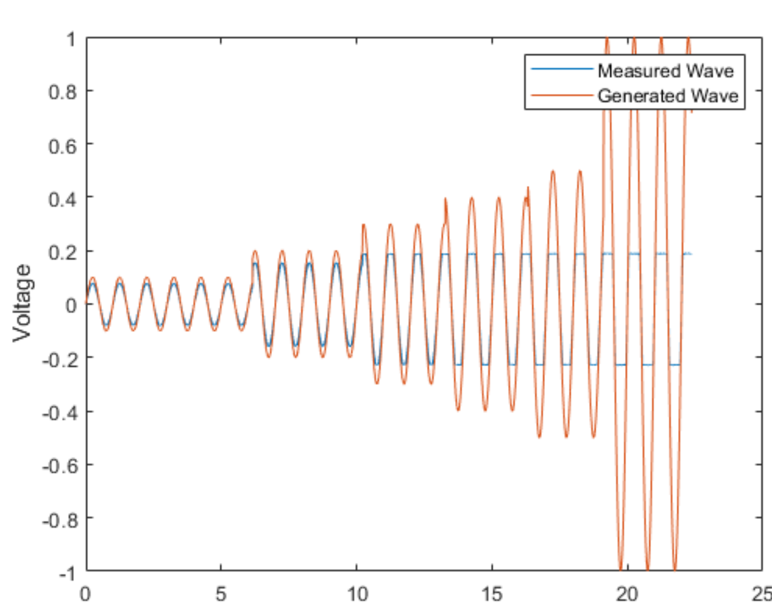
When the speaker was connected the waveform was cut off at its peaks. By testing the effect of varying the amplitude, we were able to find that the speaker itself was limiting amplitude, and, after measuring the waveform at different amplitudes, we found that the speaker could produce a smooth sine wave at a maximum amplitude of 0.2V.



1Hz sine wave generated with only positive voltage versus the unrestricted sine wave generated by Simulink.



5Hz sine wave generated with a low(25Hz) output rate output versus the sine wave generated by Simulink.



Plateauing 1Hz sine wave generated from a wave of varying amplitude powering the speaker. The original expected waveform was generated by Simulink.

**The frequencies and the output rate are much lower in these graphs than what we used in practice. This is due to a limitation in the software used for recording data. The same issues held true at higher frequencies and output rates.*

Speedgoat Real Time Target Machine

Skills Learned

Simulink
- Learned basics of simulations and real time control

Working with electronics
- Learned how to use an oscilloscope
- Improved my soldering skills
- Learned about op-amps
- Learned about factors affecting waveforms
  - The effect of refresh rate on wave quality
  - The effect of speaker limits on the waveform

Learned about basic aerodynamics
- Reynolds number
- Flow Properties
- Forces acting on aircraft
- Basic principles of aircraft design

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