

The Power of Resonance and RAM Driver Systems

Justin Whaley
Engineering Manager
Resodyn Corporation



Technical
InterChange 2026

1

What is Resonance?

Book Definition:

"Increased amplitude that occurs when the frequency of an applied force is equal or close to a natural frequency of the system on which it acts."



The Tacoma Narrows Bridge: November 1940



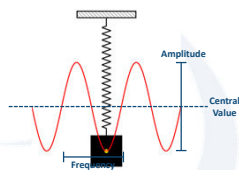
2

Technical
InterChange 2026

2

Background – Oscillations and Frequency

- An Oscillation is a Back-and-Forth Movement about some Central Value
- Frequency is the Speed at which the Oscillation Occurs
 - Defined in Hz (Number of Cycles per Second)
- Amplitude is the distance traveled during half of an oscillation
 - We will measure peak-to-peak amplitude



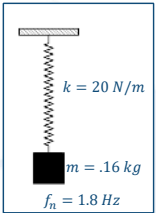
3

Technical
InterChange 2026

3

Background - Natural Frequency

- All Physical Structures have a Natural Frequency!
- This is the Frequency at which the Structure will Tend to Vibrate when Subjected to Certain External Forces
- Depends on the Relationship Between Stiffness and Mass:
 - f_n : natural Frequency
 - k : spring stiffness
 - m : mass

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$


$k = 20 \text{ N/m}$
 $m = .16 \text{ kg}$
 $f_n = 1.8 \text{ Hz}$

Resodyn
ACOUSTIC MIXERS

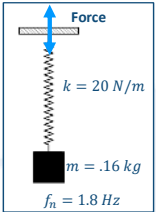
4

Technical
InterChange 2026

4

Background - Natural Frequency

- All Physical Structures have a Natural Frequency!
- This is the Frequency at which the Structure will Tend to Vibrate when Subjected to Certain External Forces
- Depends on the Relationship Between Stiffness and Mass:
 - f_n : natural Frequency
 - k : spring stiffness
 - m : mass

$$f_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}}$$


$k = 20 \text{ N/m}$
 $m = .16 \text{ kg}$
 $f_n = 1.8 \text{ Hz}$

Providing an Oscillating Force at the Natural Frequency Creates Resonance

Resodyn
ACOUSTIC MIXERS

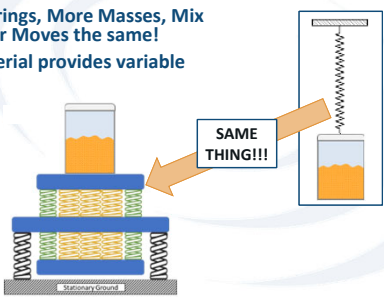
5

Technical
InterChange 2026

5

Simple Spring-Mass to RAM

- RAM Mixer is a More Complicated Spring-Mass System
- More Springs, More Masses, Mix Container Moves the same!
- Mix Material provides variable Damping



SAME THING!!!

Resodyn
ACOUSTIC MIXERS

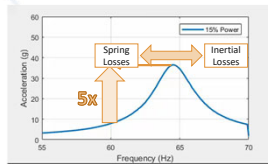
6

Technical
InterChange 2026

6

Why Resonant Acoustic Mixing?

- Resonance is not Needed for Mixing
- Energetic Collisions and Acoustic Waves are Needed for Mixing
- High Amplitude Vibrations Create Energetic Collisions and Acoustic Waves
- Resonance Efficiently Produces "Increased Amplitude Vibrations"



Resodyn
ACOUSTIC MIXERS

7

Technical
InterChange 2026

7

Controlling Resonance in RAM

- RAM Mixers use two distinct Drive Systems
 - Linear Voice Coil Motor
 - Rotational Servo Motors
- Control System Accomplishes Two Goals
 - Adjust frequency to maintain resonant condition
 - Adjust power to maintain a set acceleration (g)



Resodyn
ACOUSTIC MIXERS

8

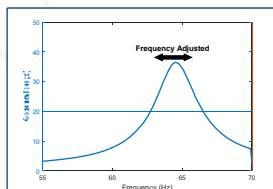
Technical
InterChange 2026

8

Embedded Controller Overview

Embedded Controller Accomplishes Two Goals

1. Maintain operation at the resonant condition
 - Frequency Control is Transparent to the User



Resodyn
ACOUSTIC MIXERS

9

Technical
InterChange 2026

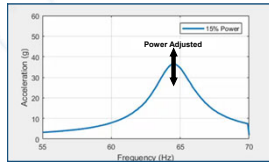
9

Embedded Controller Overview

Embedded Controller Accomplishes Two Goals

2. Adjust power to maintain a set acceleration

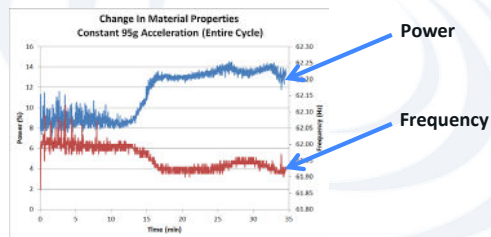
- Acceleration is the primary metric for Acoustic Mixing
- RAM Mixer Adjusts Driver Power to Obtain Acceleration Setpoint
- Operation is Analogous to Automobile Cruise Control



10

Acceleration Control

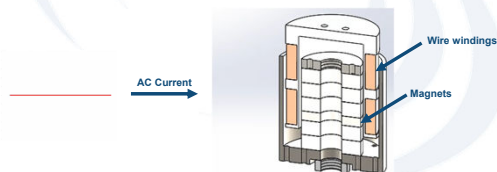
- Material Properties can Change During a Mix Cycle
- Changing Material Properties Require Frequency and Power Adjustments



11

Linear Motor - Drive System

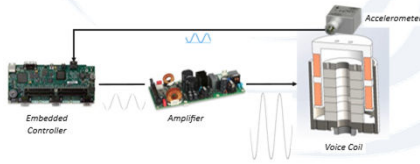
- Linear Voice Coil Motor Provides Input Force
- Operation Similar to a Speaker
- Alternating Current Generates Magnetic Field that Couples with a Magnet and Generates Force



12

Linear Motor - Control System

- **Embedded Controller**
 - Acceleration tracking
 - Drive signals to amplifier
 - Reads accelerometer
 - Communicates with User Interface
- **Amplifier Supplies Alternating Current to Voice Coil**
- **Voice Coil Provides Driving Force to Resonator**



Resodyn
ACOUSTIC MIXERS

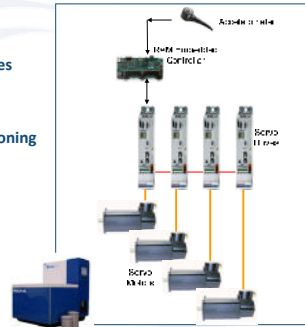
13

Technical
InterChange 2026

13

Rotational Motor - Control System

- **Embedded Controller**
 - Acceleration tracking
 - Reference signals to drives
 - Reads accelerometer
- **Servo Drives**
 - Control speed and positioning of motors
 - Generic input/output



Resodyn
ACOUSTIC MIXERS

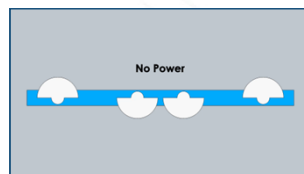
14

Technical
InterChange 2026

14

Rotational Motor - Drive System

- **Four Eccentric Masses Create Variable Vertical Force**
- **A Motor Pair is Necessary to Cancel Sideways Forces**
- **Two Pairs are Necessary for Variable Input Force**
- **Vertical Force Applied at Resonance**
 - All Four Motor Velocity Changes with the Natural Frequency



Resodyn
ACOUSTIC MIXERS

15

Technical
InterChange 2026

15

Summary

- Mass and Spring Stiffness Establish RAMs Natural Frequency and Amplitude
- Resonance makes the Highly Energetic Conditions Needed for Acoustic Mixing Possible
- The Control System Keeps the Mixer at the Acceleration Setpoint and at Resonance, even with Changing Mix Material Properties
- Advanced Drive Systems are Used to Provide the Input Force for all RAM Mixers



16

Technical
InterChange 2026

16

Thank you for your time
and attention.



Technical
InterChange 2026

17
