Resonator Design and Capacity

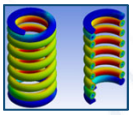
Zach Martineau, PE
Senior Mechanical Engineer

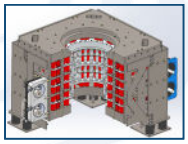
Resodyn ACOUSTIC MIXERS

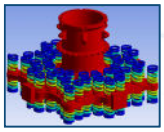
Technical InterChange 2025

Resonator Design and Capacity

- Resonator Design
  - Resonance
  - Three Masses
- Resonator Capacity
  - Classifying Payload Mass
  - LabRAM II Mix Capacity



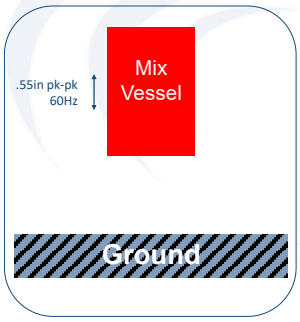




Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Resonator Design- Power Obstacle

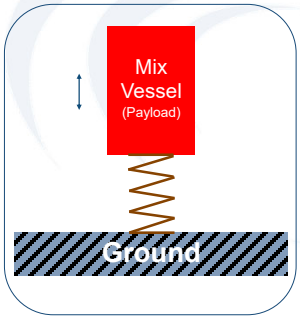


- Oscillating Motion Causes Mixing
  - ≈60 Hz
  - 100g of acceleration
- How to Power It?
  - 5 lbm – 2,600 W (3.5 HP)
  - 375 lbm – 195 KW (260 HP)
  - 3000 lbm – 1.56 MW (2150 HP)

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Resonator Design- Payload in Resonance



- Solution
  - Add a spring
  - Resonant Condition:

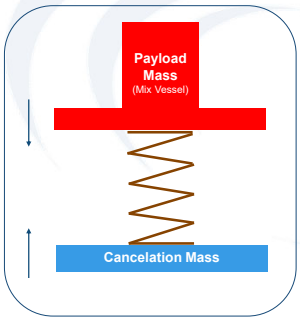
$$f \propto \sqrt{\frac{K}{m}}$$

- Problem
  - Astronomical force to ground
  - 375 lbm payload results in ± 37,500 lbf

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Resonator Design- Cancelation Mass

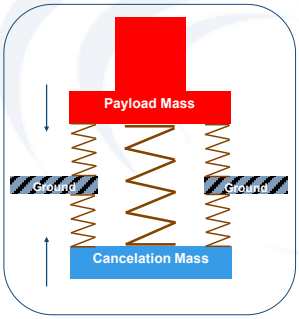


- Solution
  - Add a cancelation mass
- Problem
  - How do you hold on to it?

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Resonator Design- Cancelation Mass

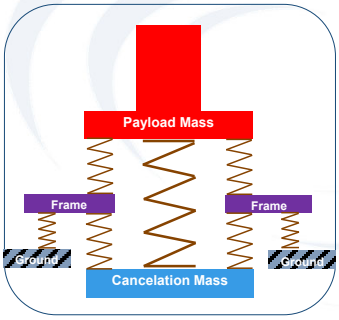


- Solution
  - Add springs to ground between the masses
- Problem
  - Payload variation means the system isn't always perfectly tuned resulting in force to ground

Resodyn ACOUSTIC MIXERS

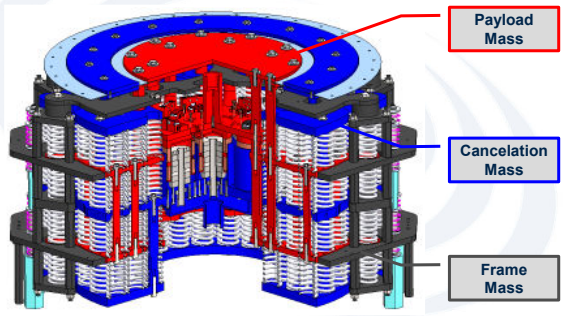
Technical InterChange 2025

Resonator Design- Frame Mass



- Solution
  - Add a third mass (frame) to cancel the remaining force to ground
  - Maximum alternating force to ground from a RAM55 is ±80 lbf

Resonator Design



Capacity

Make/Model	Payload Classification
Ford F150	"Half Ton"
Ford F250	"Three Quarter Ton"
Ford F350	"One Ton"

Mixer Capacity

Model	Payload Classification
LabRAM I	1.1 lbm / 0.50 kg
LabRAM II	2.2 lbm / 1.0 kg
OmniRAM	11 lbm / 5.0 kg
RAM 5	80 lbm / 36 kg
RAM 55	924 lbm / 420 kg

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Classifying Payload Mass: Dead Mass

- Dead Mass: Mass That Does Not Absorb Energy
  - Vessel Holder
  - Vessel
  - RTD Probes
  - Fasteners
  - Components that do not move relative to the payload plate

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Classifying Payload Mass: Live Mass

- Live Mass- Mass That Absorbs Energy
  - Powder
  - Liquids
  - Paste
  - Coolant
  - Mass that moves relative to the payload plate

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Classifying Payload Mass: Total Equivalent Mass

$$M_{Eqv} = M_{Dead} + M_{Live} \times C$$

- C- Coupling Coefficient (Determined Experimentally)
- Coupling Factors:
  - Mix material properties
  - Vacuum
  - Headspace
  - Vessel geometry
  - And more…

Classifying Payload Mass: 100g Equivalent Mass Limits

Model	Payload Classification	Maximum 100g Equivalent Mass
LabRAM I	1.1 lbm / 0.50 kg	4.2 lbm / 1.9 kg
LabRAM II	2.2 lbm / 1.0 kg	5.5 lbm / 2.5 kg
OmniRAM	11 lbm / 5.0 kg	80 lbm / 36 kg
RAM 5	80 lbm / 36 kg	375 lbm / 170 kg
RAM 55	924 lbm / 420 kg	3100 lbm / 1400 kg

$$M_{Eqv} = M_{Dead} + M_{Live} \times C$$

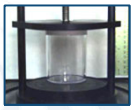
Classifying Payload Mass: Examples

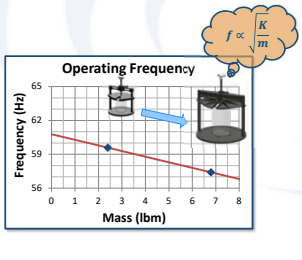
Model	Payload Classification	Maximum 100g Equivalent Mass
LabRAM II	2.2 lbm	5.5 lbm

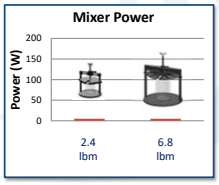
	Standard Vessel Holder 8oz PP Jar	2.4 lbm
	Oversized Vessel Holder 32oz Glass Jar	6.8 lbm
	Standard Vessel Holder 8oz PP Jar 1.0 lbm Sand	3.4 lbm

Classifying Payload Mass: Examples

- Increasing the Dead Mass Lowers the Operating Frequency but does not Change the Mix Power

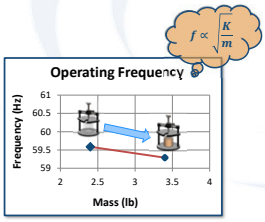


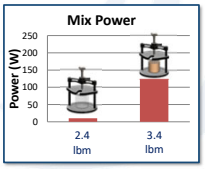




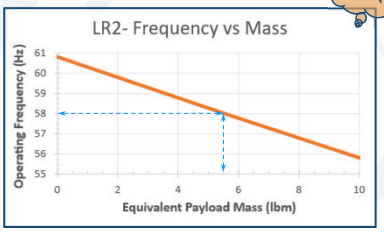
Classifying Payload Mass: Examples

- Adding Live Mass Changes both the Operating Frequency and Mix Power



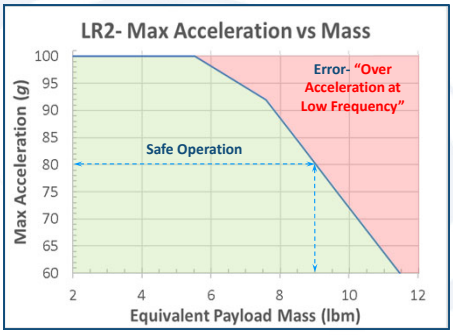


LabRAM II Capacity: Operating Conditions



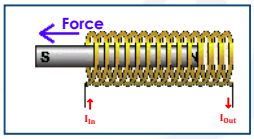
$$M_{Eqv} = M_{Dead} + M_{Live} \times C$$

LabRAM II Capacity: Acceleration De-Rate Conditions



LabRAM II Capacity: Available Power

- Work = Force x Displacement
- Usable Power at 100g: 600 W
- For Example:
  - If a live mass absorbs 250 $\frac{W}{lbm}$
  - $\frac{600\ W}{250\ \frac{W}{lbm}} = 2.4\ lbm\ Max$
  - Mixing more will result in error- "Amplifier Over Current"



Mixer Capacity: Available Power

Model	Maximum Available Power
LabRAM I	230 W
LabRAM II	600 W
OmniRAM	4.2 kW
RAM 5	24.7 kW
RAM 55	235 kW

Mixer Design and Capacity- Summary

- Resonance is Paramount to Efficient RAM Operation
- Three Masses are Required to Manage Floor Vibrations
- Payload Mass (Equivalent Mass) is:

$$M_{Eqv} = M_{Dead} + M_{Live} \times C$$

- Resonators Have Both Mass and Power Limits

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025

Thank you for your time and attention.

Resodyn ACOUSTIC MIXERS

Technical InterChange 2025