Communication through Physical Vibration

Nirupam Roy

ECE598HH Guest Lecture
UIUC, October 4, 2016

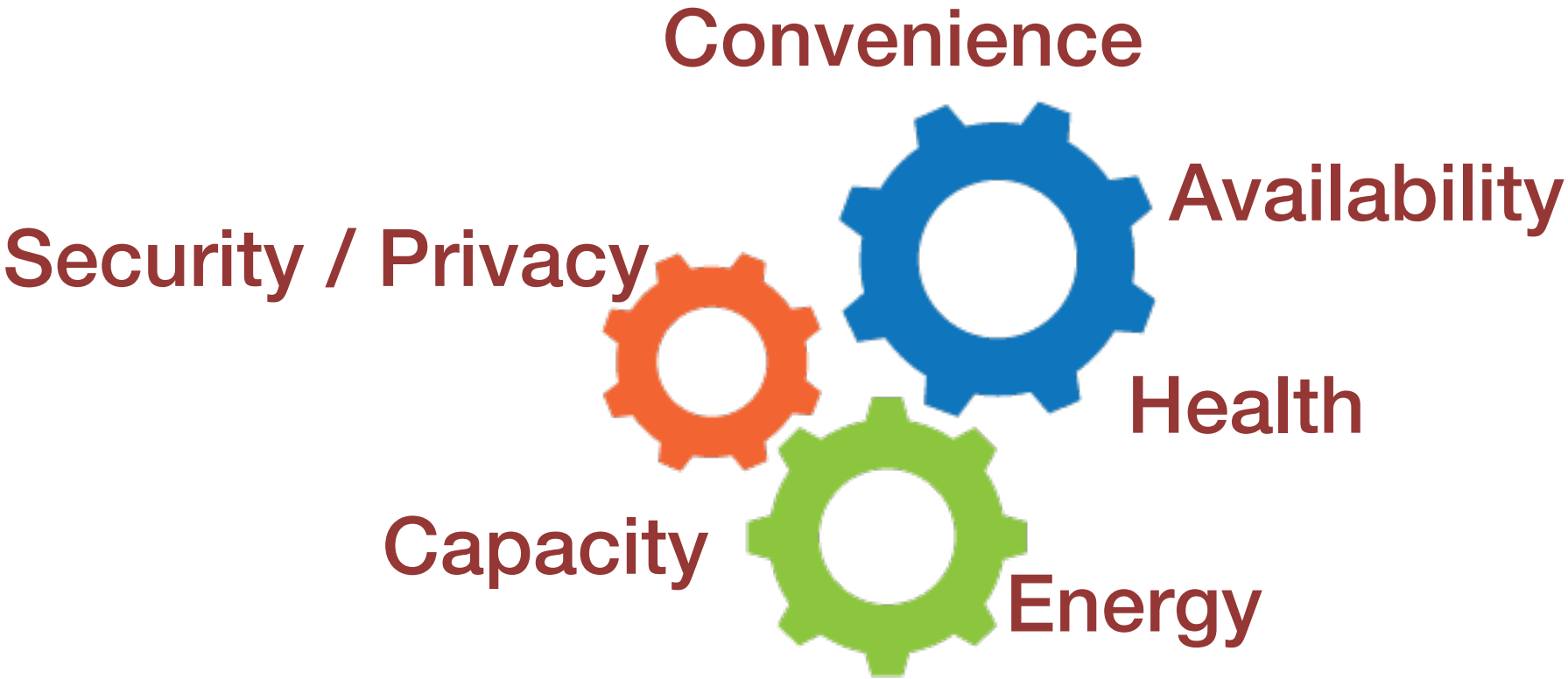
Short range communication: a new need of this decade

Short range communication: a new need of this decade

Emerging technologies for short range

Driving forces of short range communication research

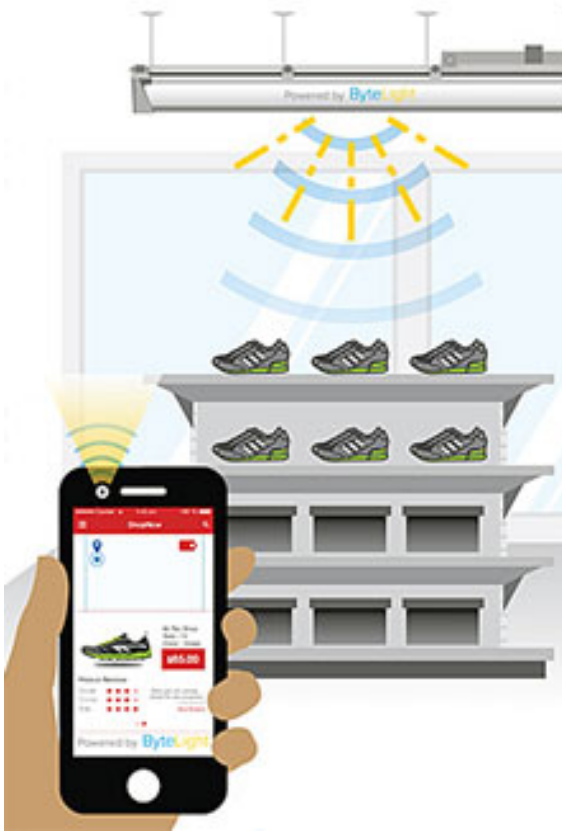
Emerging technologies for short range



Driving forces of short range communication research

Emerging technologies for short range

Visible Light Communication

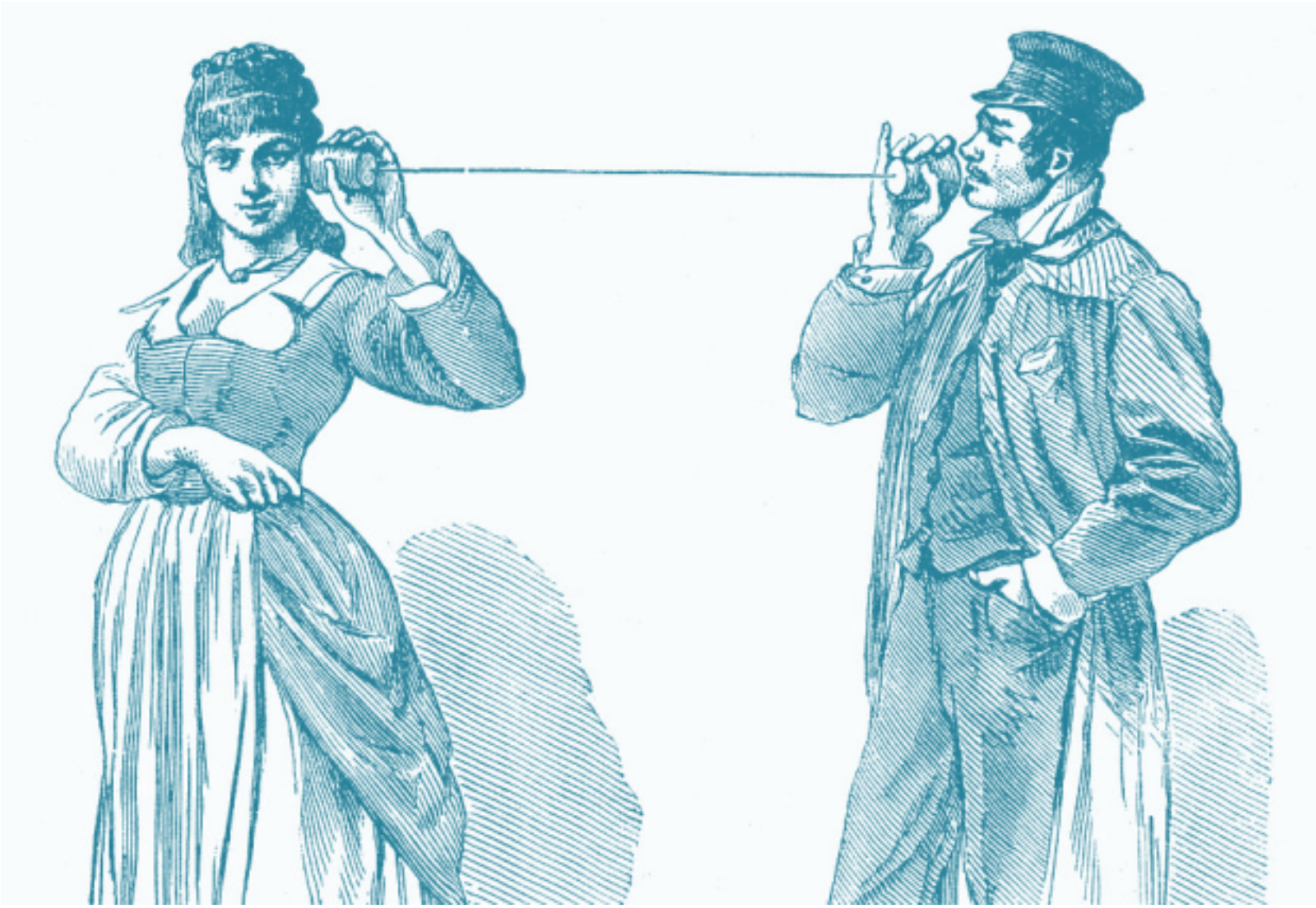


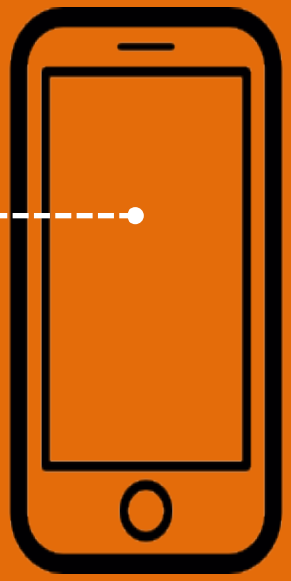
bytelight

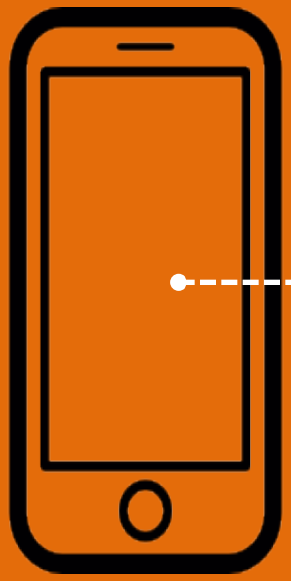
Acoustic NFC

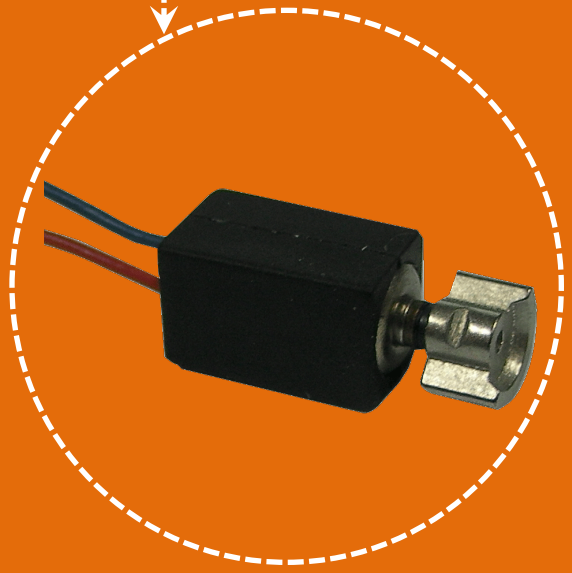
Zoosh
Powered by Naratte

Physical vibration:
a new mode of communication

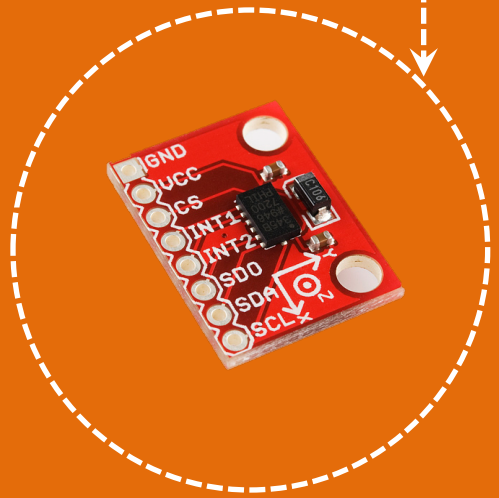




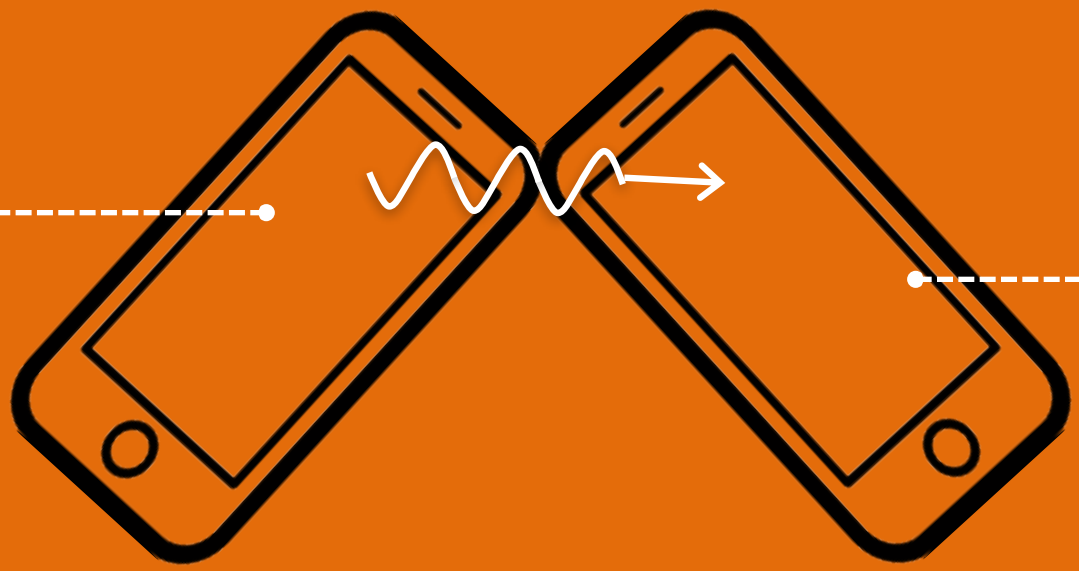


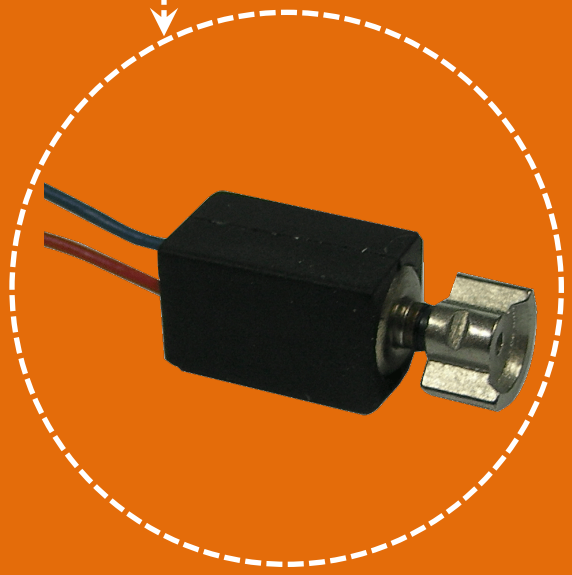


Vibration Motor

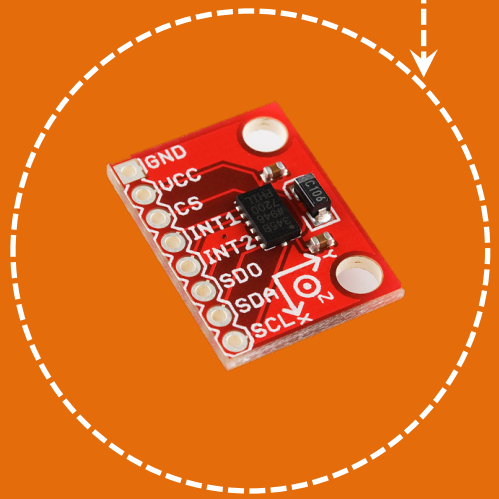


Accelerometer



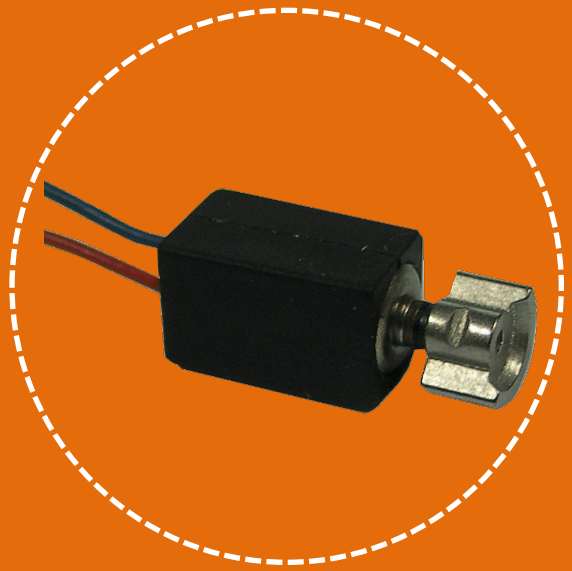


Vibration Motor

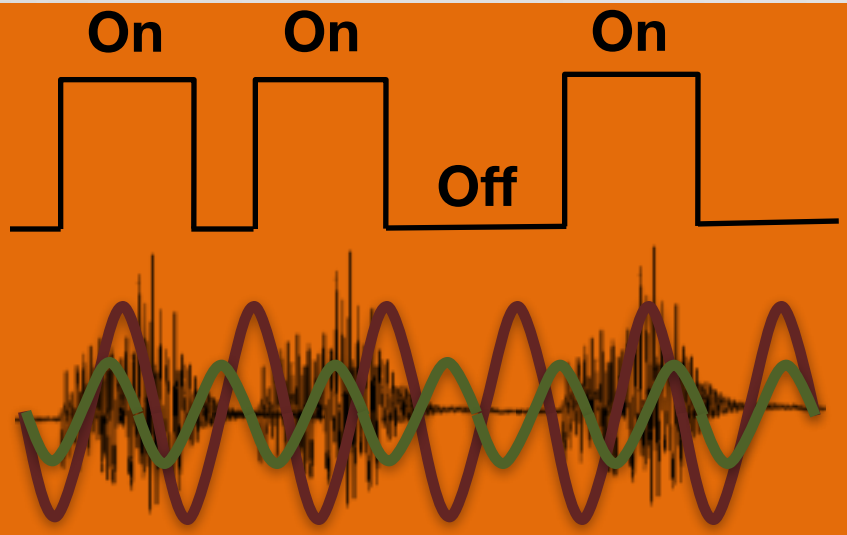


Accelerometer

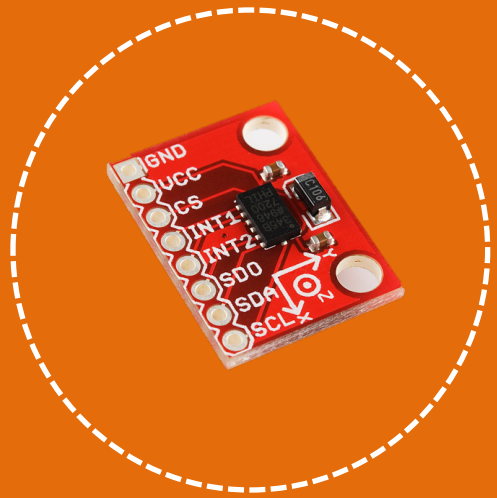
Morse Code Key



Vibration Motor



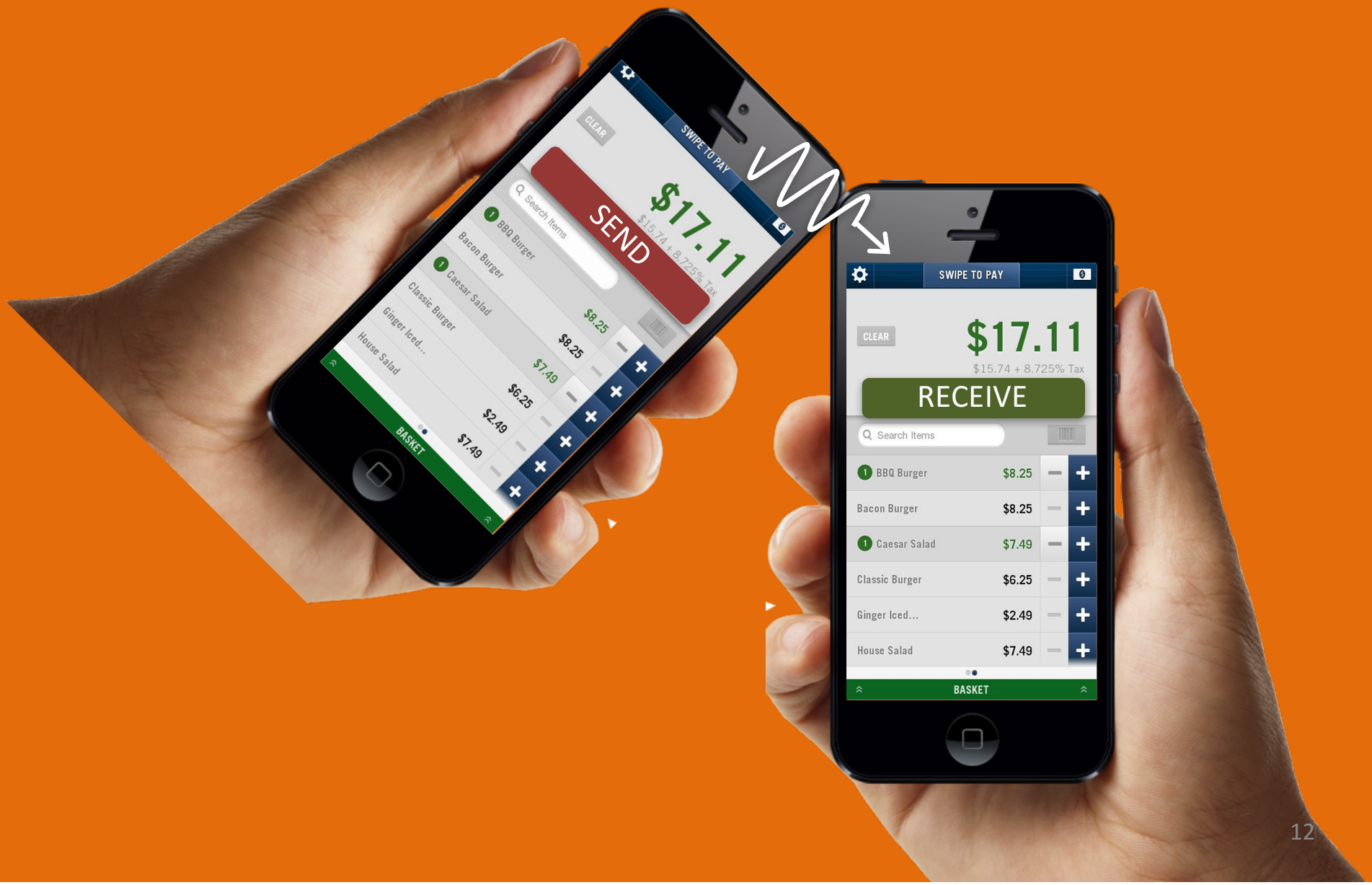
Modulated vibration



Accelerometer

Applications: Mobile Money Transfer

Applications: Mobile Money Transfer



Applications: Authentication with Ring

Applications: Authentication with Ring

Applications: Authentication with Ring

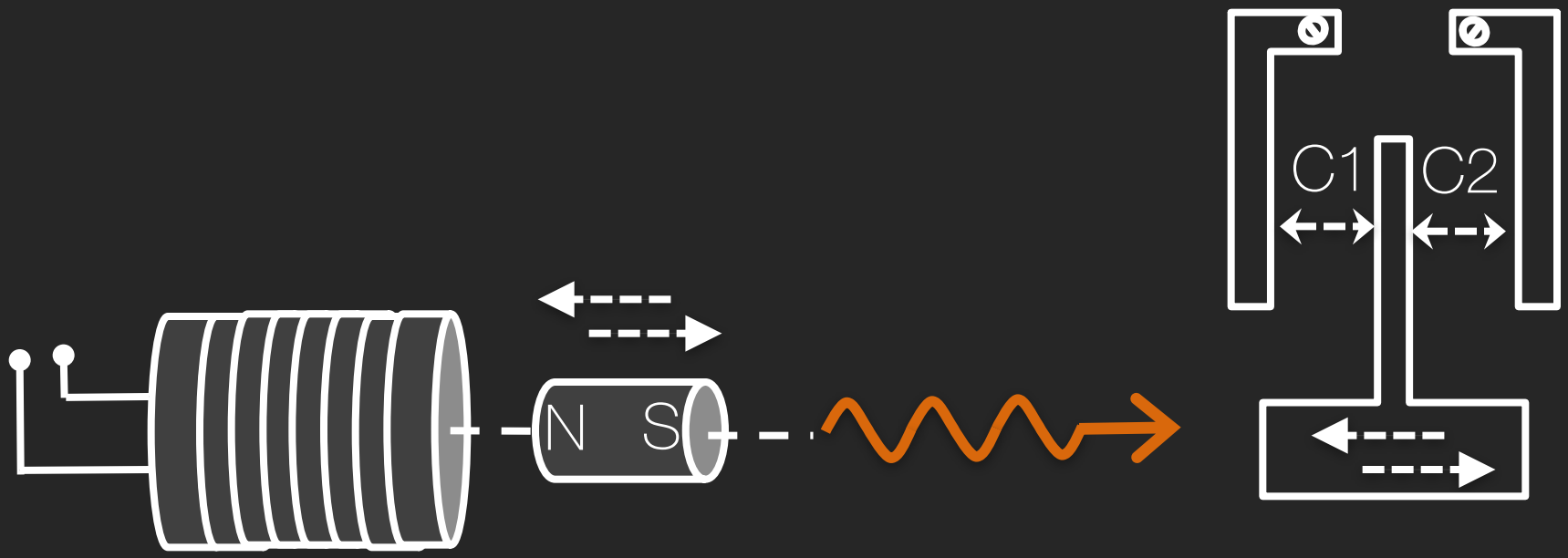
Applications: Body-Area Network

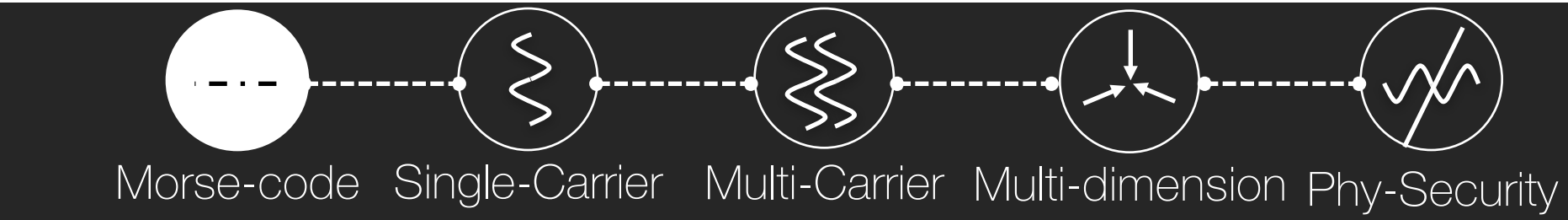
Or…may be you can come up with a better one

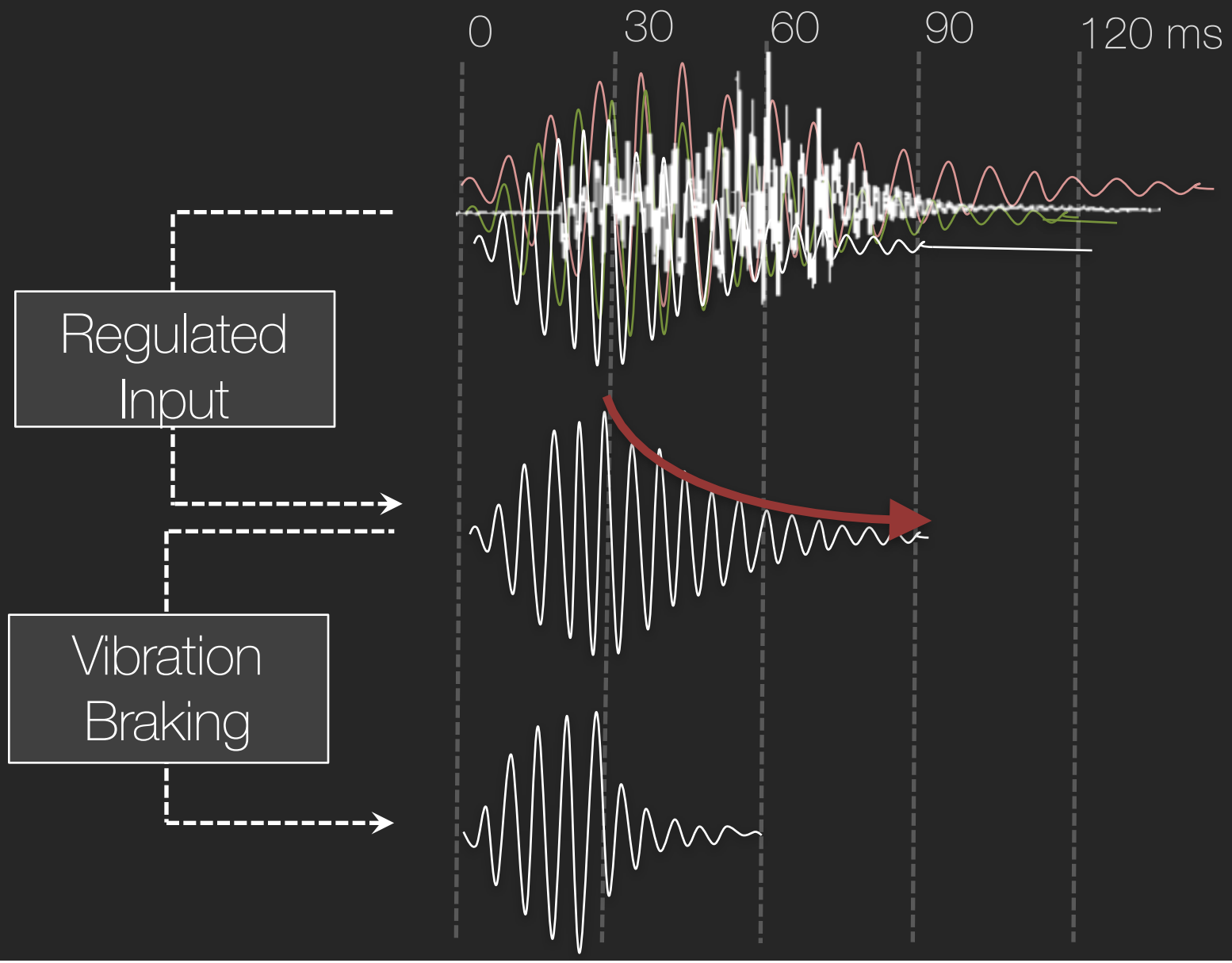
Morse-code Single-Carrier Multi-Carrier Multi-dimension Phy-Security

Vibration Motor

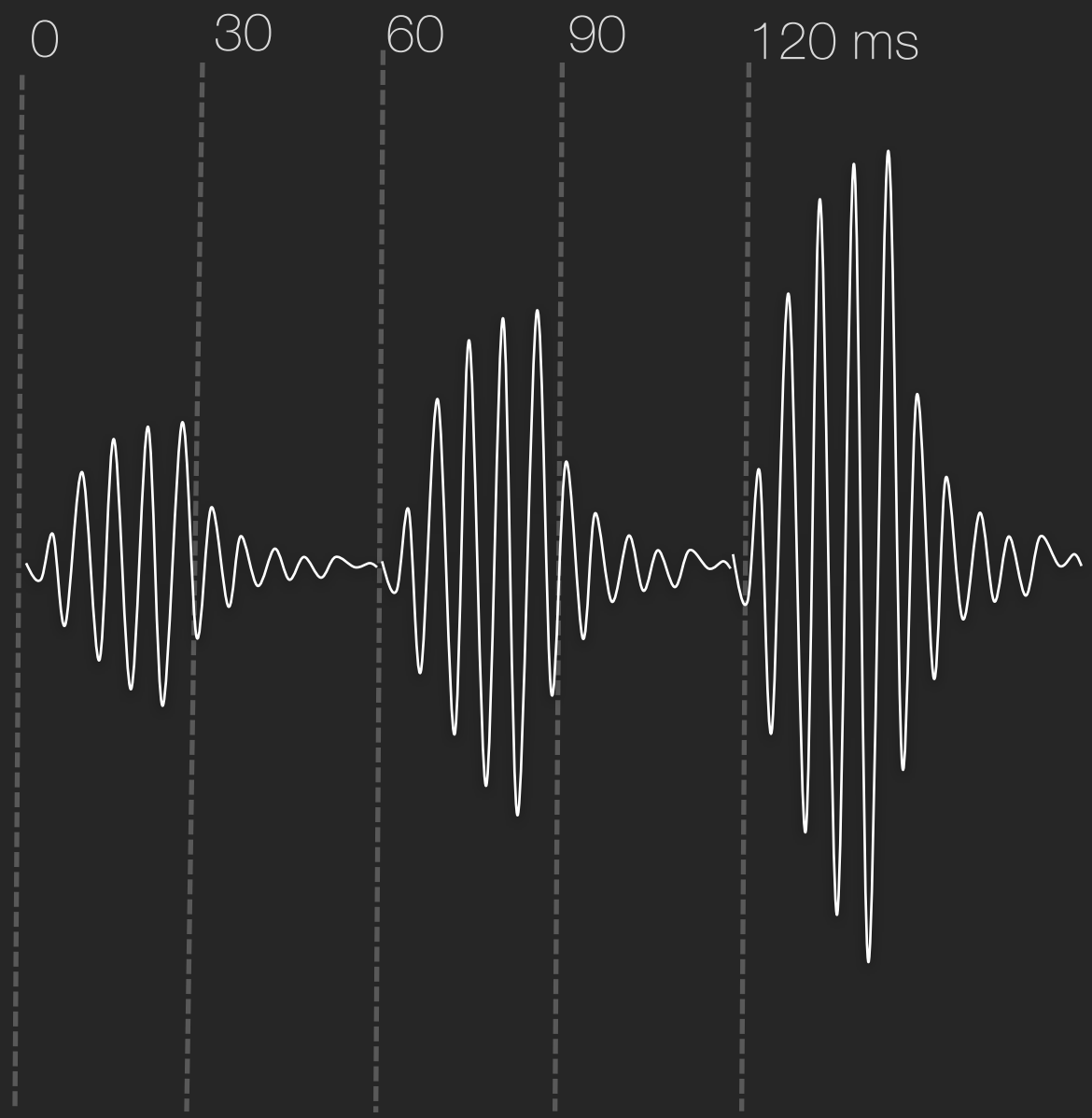
Accelerometer



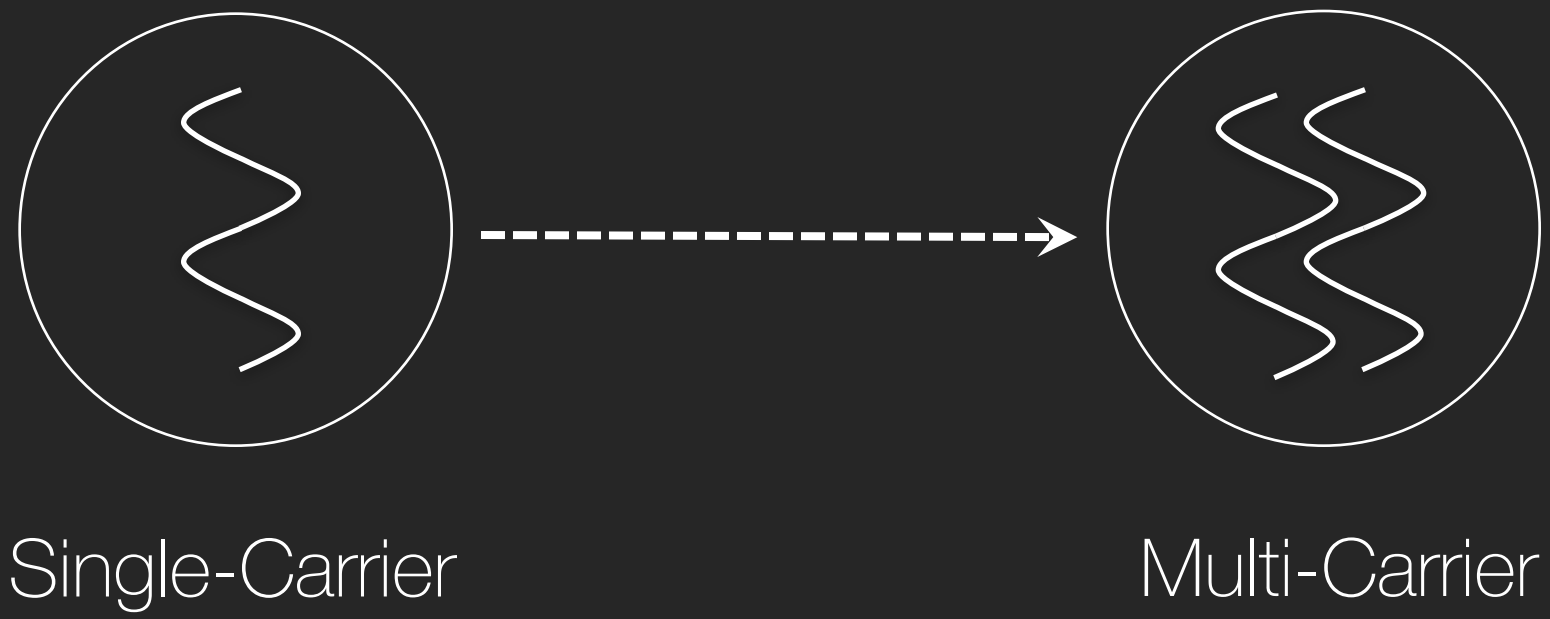

Morse-code
Single-Carrier
Multi-Carrier
Multi-dimension
Phy-Security


0
30
60
90
120 ms
Regulated Input
Vibration Braking

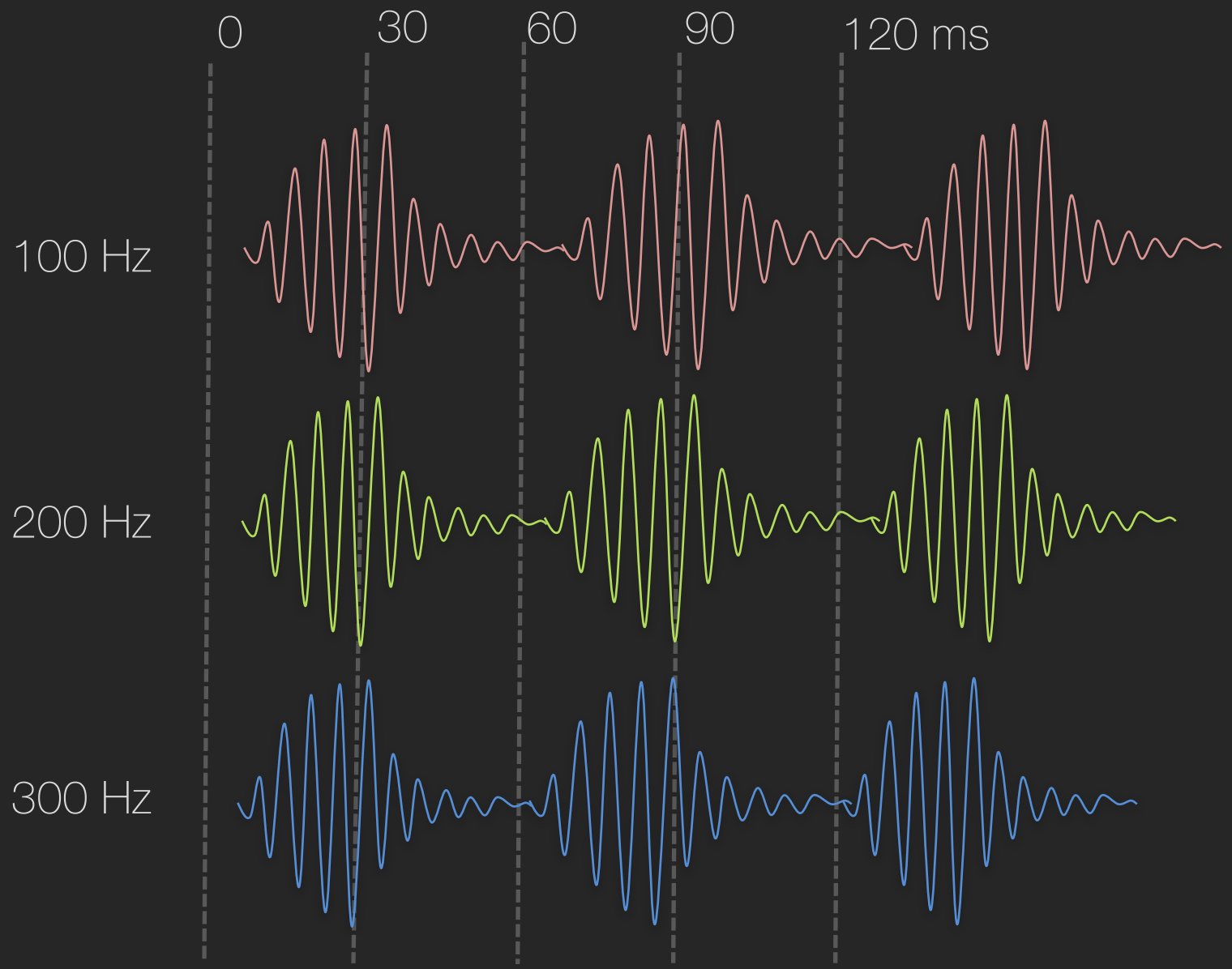

Morse-code
Single-Carrier
Multi-Carrier
Multi-dimension
Phy-Security


0
30
60
90
120 ms

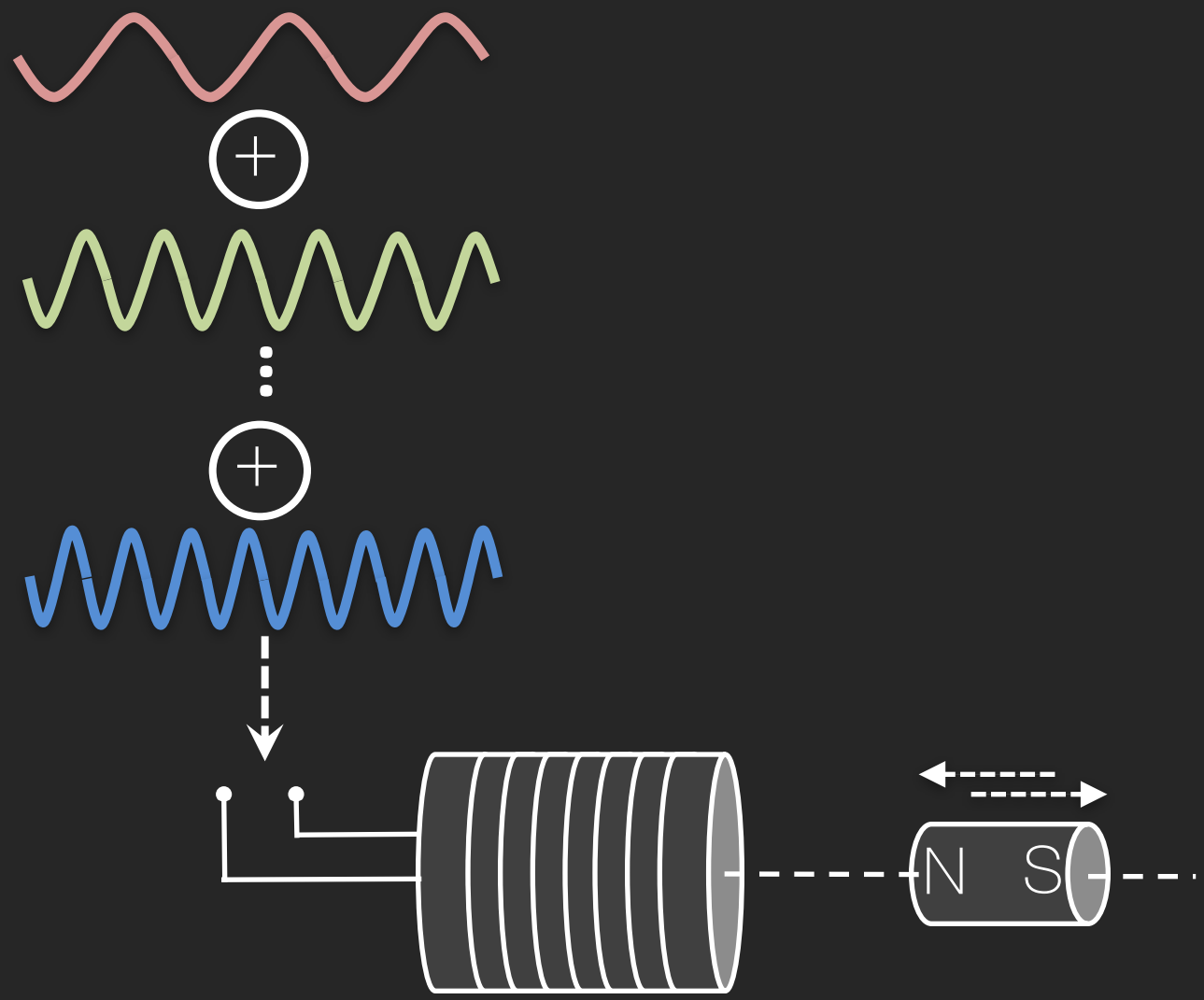

Morse-code
Single-Carrier
Multi-Carrier
Multi-dimension
Phy-Security

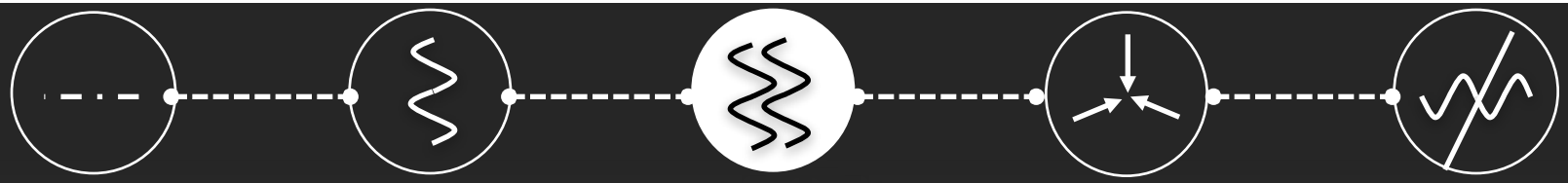

Single-Carrier
Multi-Carrier

Morse-code Single-Carrier Multi-Carrier Multi-dimension Phy-Security

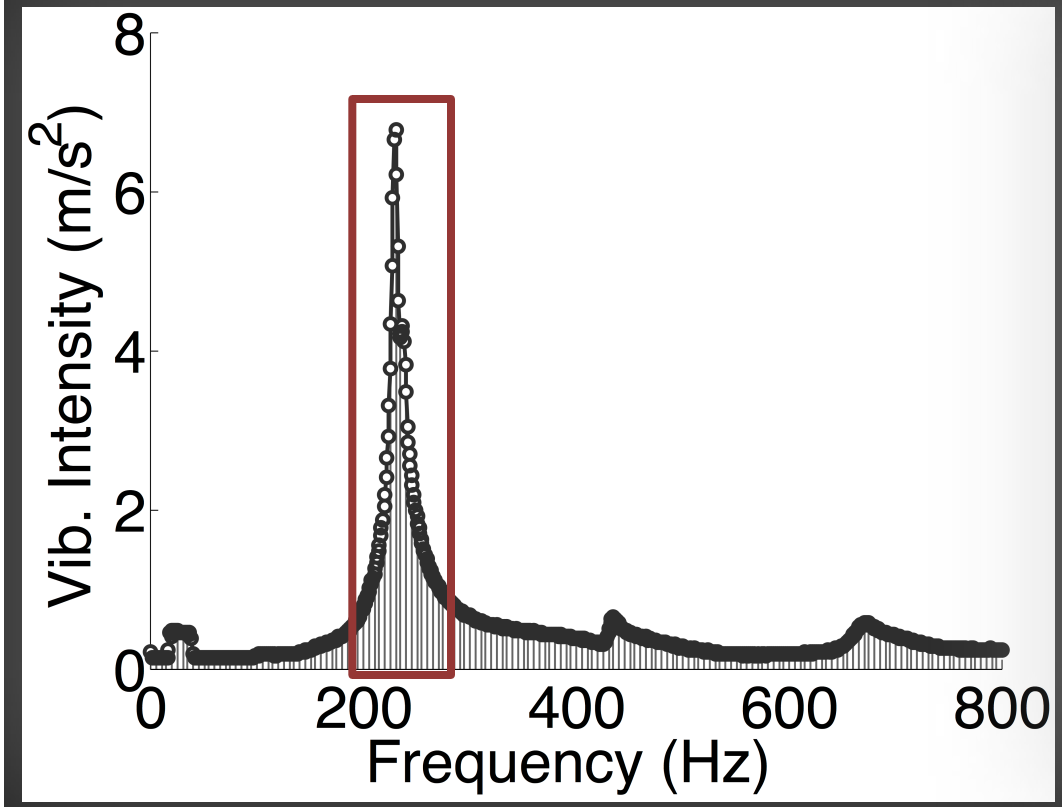


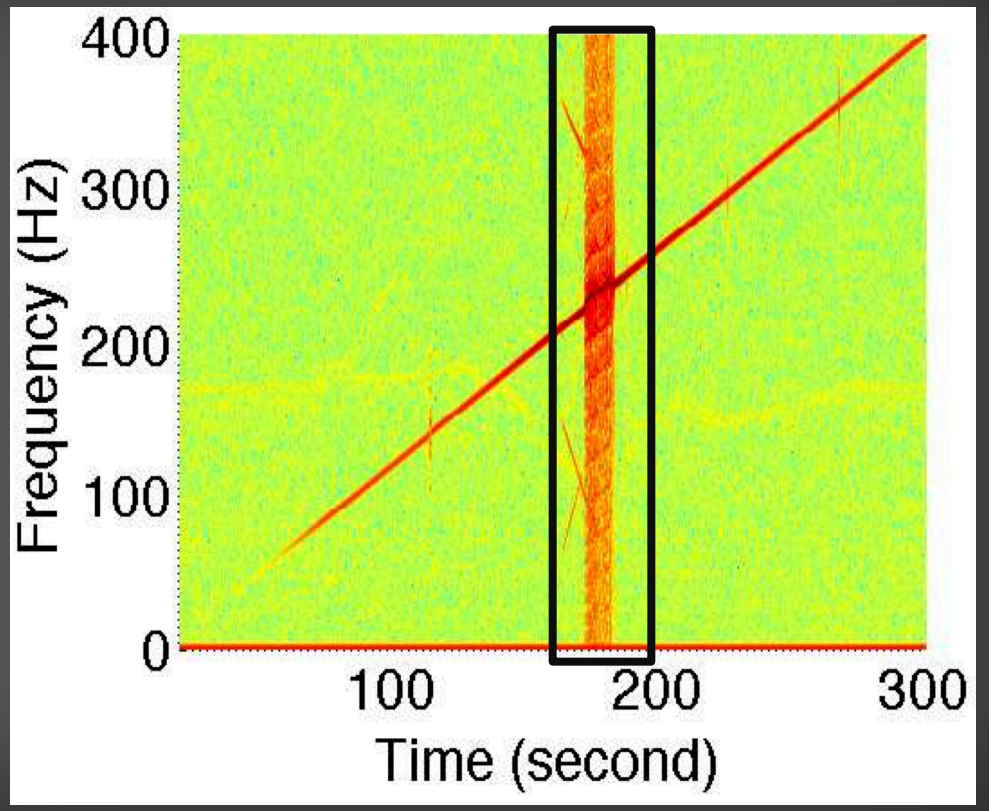

Morse-code
Single-Carrier
Multi-Carrier
Multi-dimension
Phy-Security

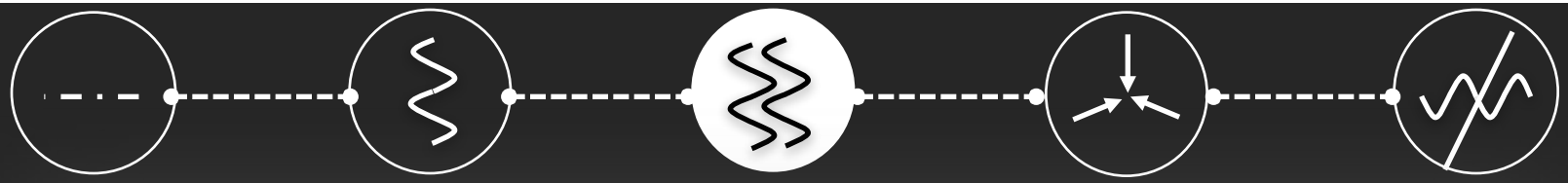

N
S



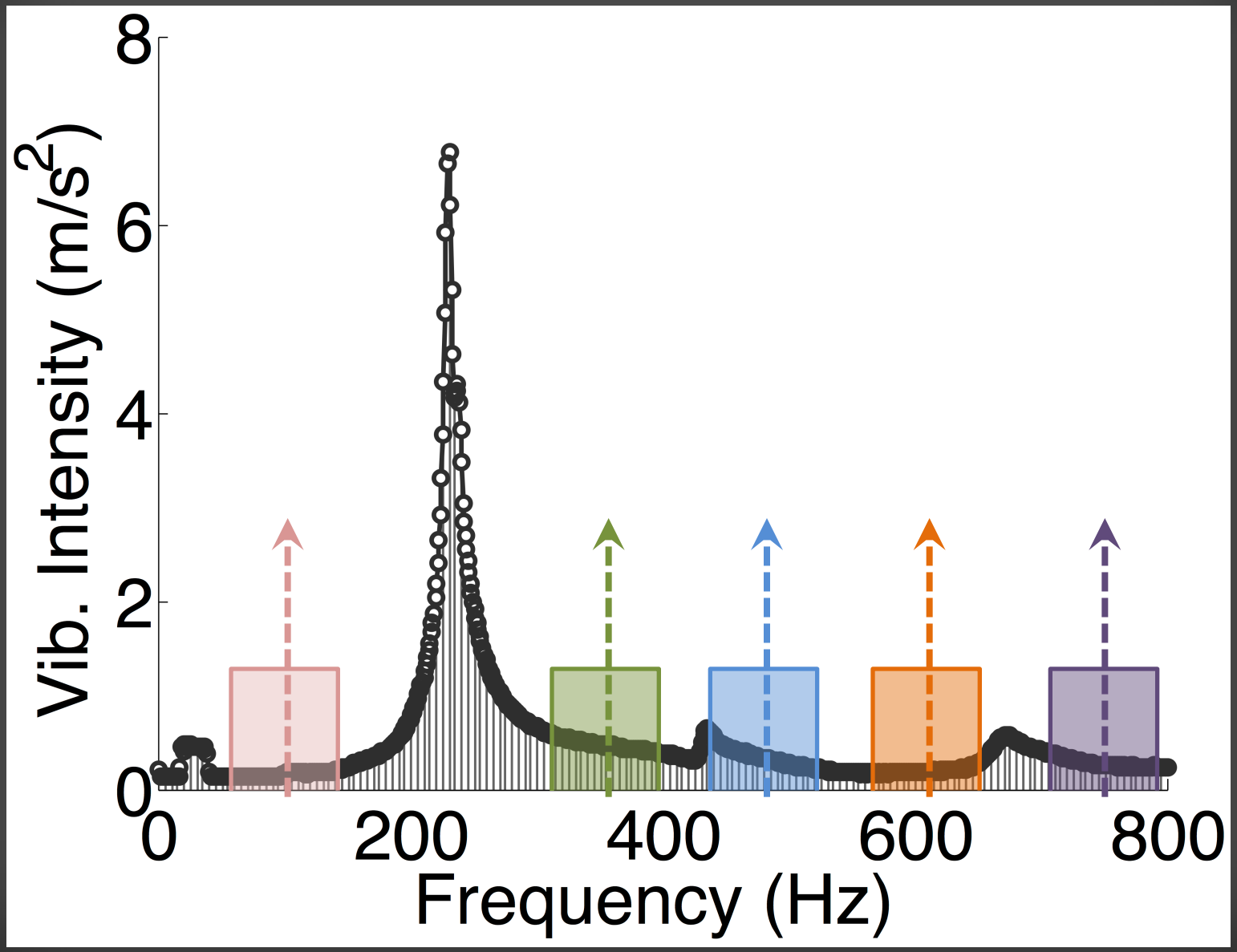
Morse-code Single-Carrier Multi-Carrier Multi-dimension Phy-Security

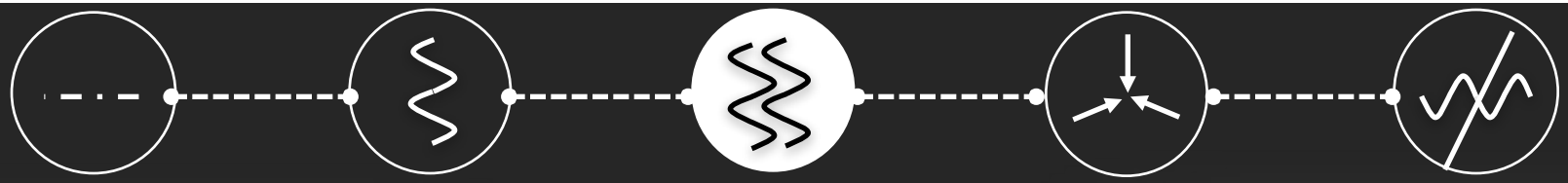




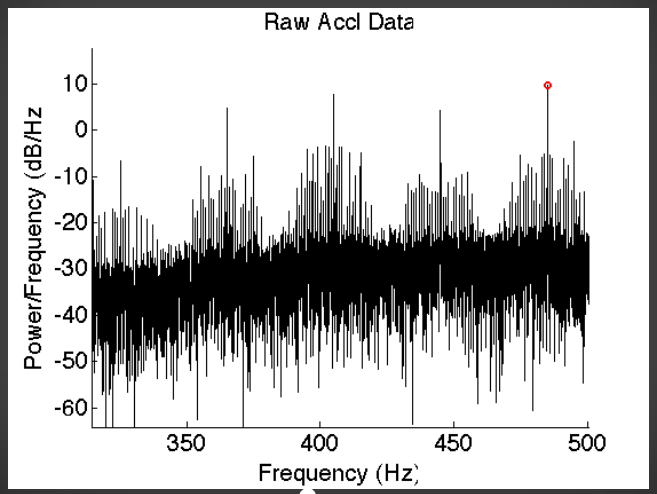


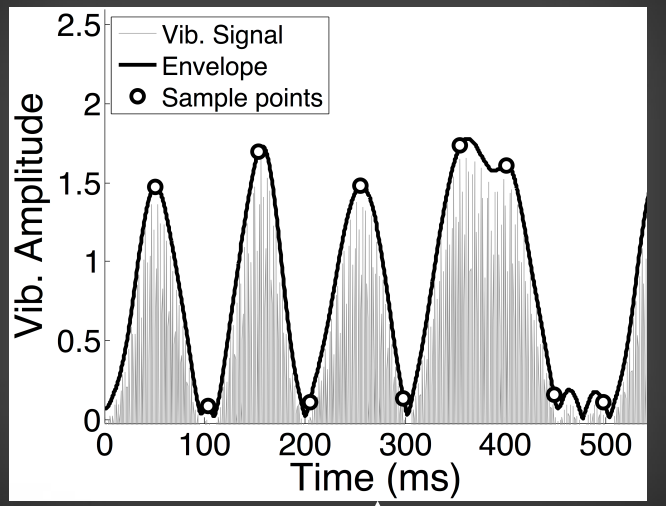
Morse-code Single-Carrier Multi-Carrier Multi-dimension Phy-Security



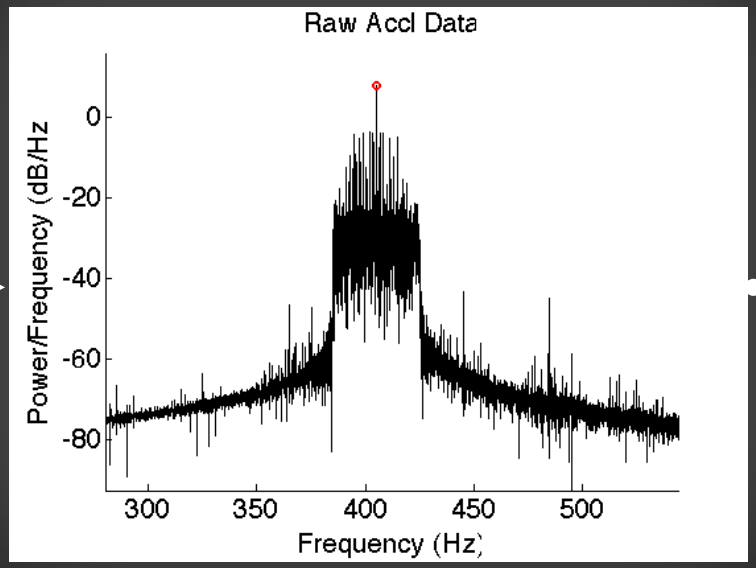


Morse-code Single-Carrier Multi-Carrier Multi-dimension Phy-Security



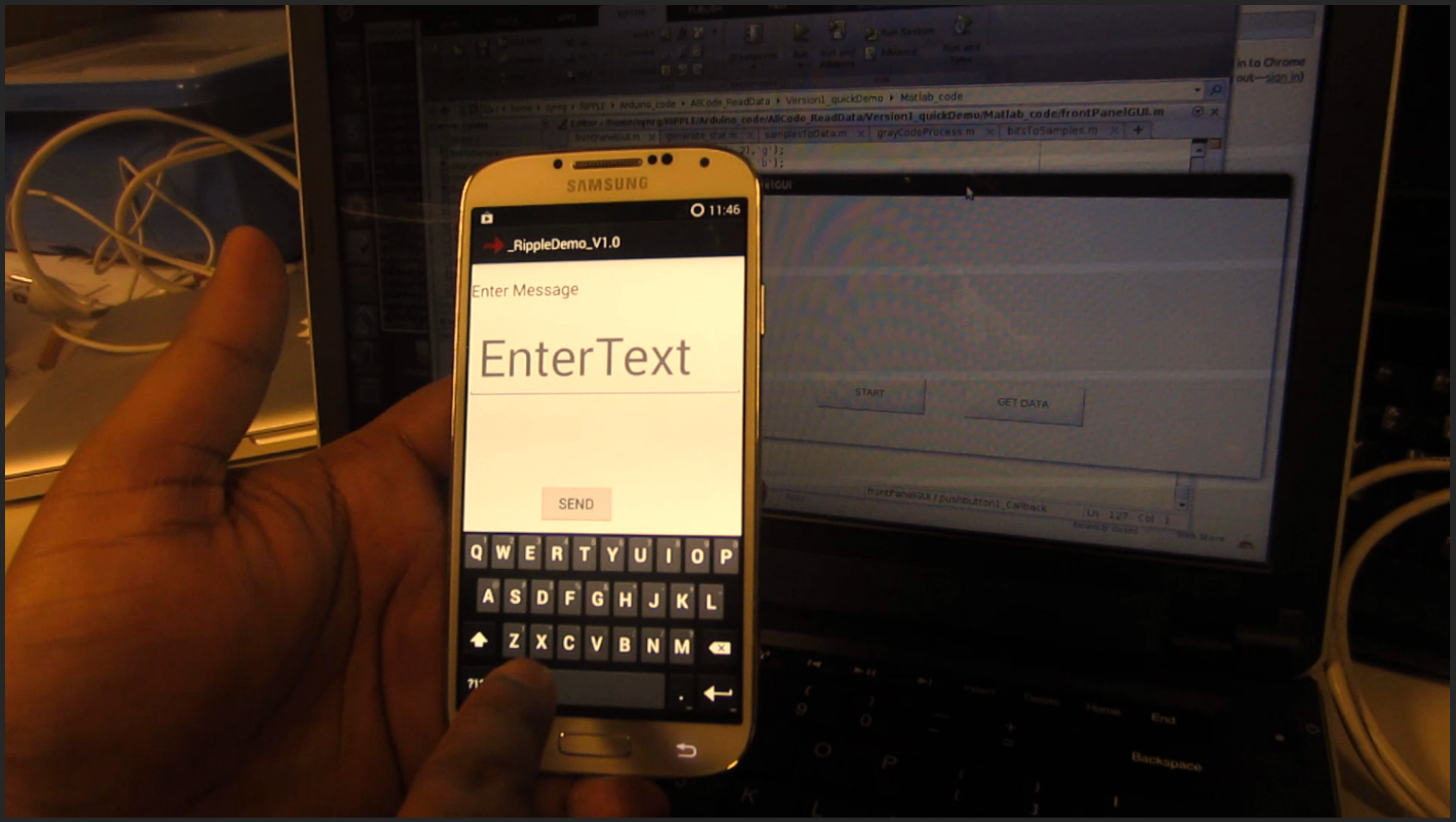


Filtering

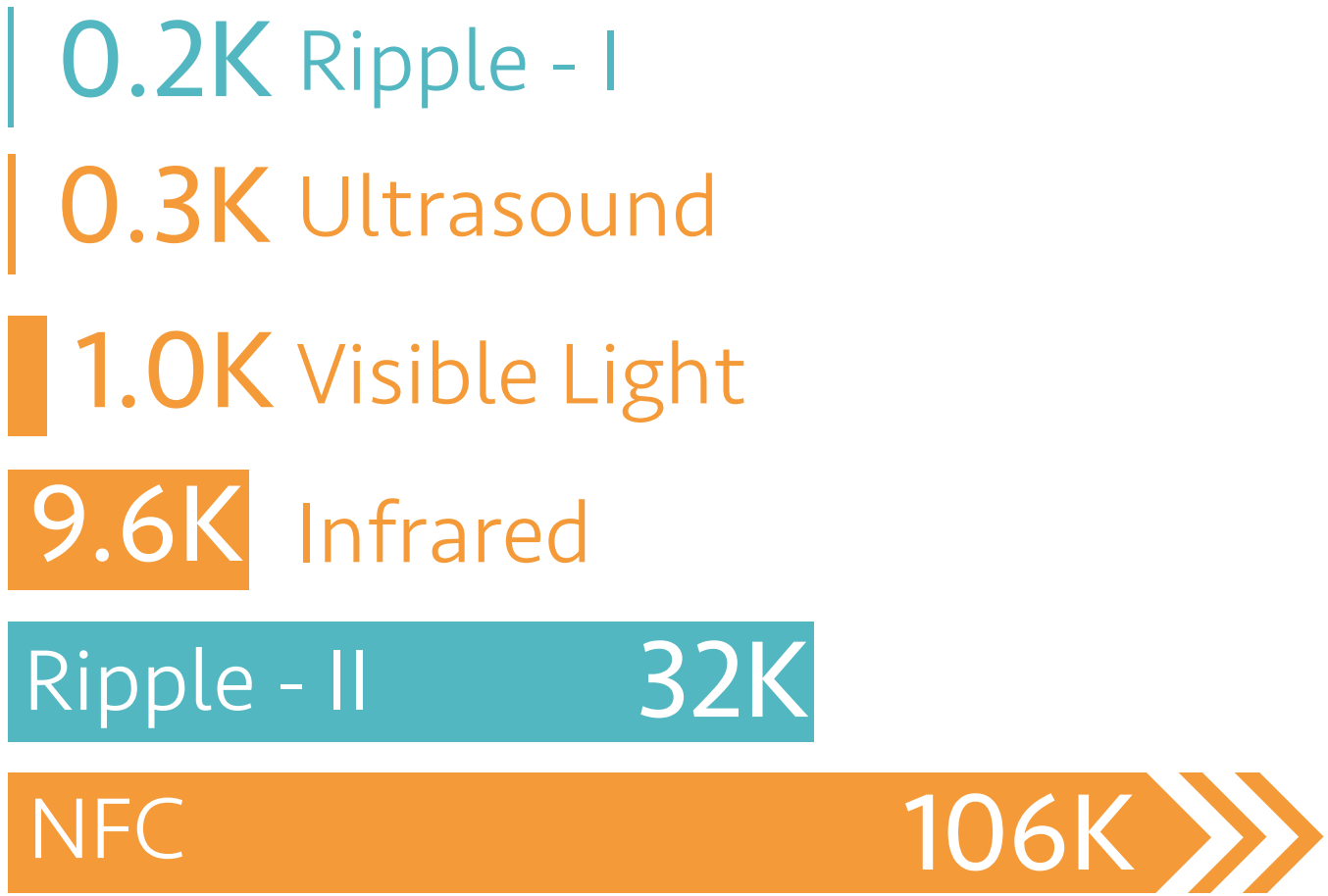


Envelope Detection

Demo


SAMSUNG
11:46
_RippleDemo_V1.0
Enter Message
EnterText
SEND
START
GET DATA

Search for a better Ripple

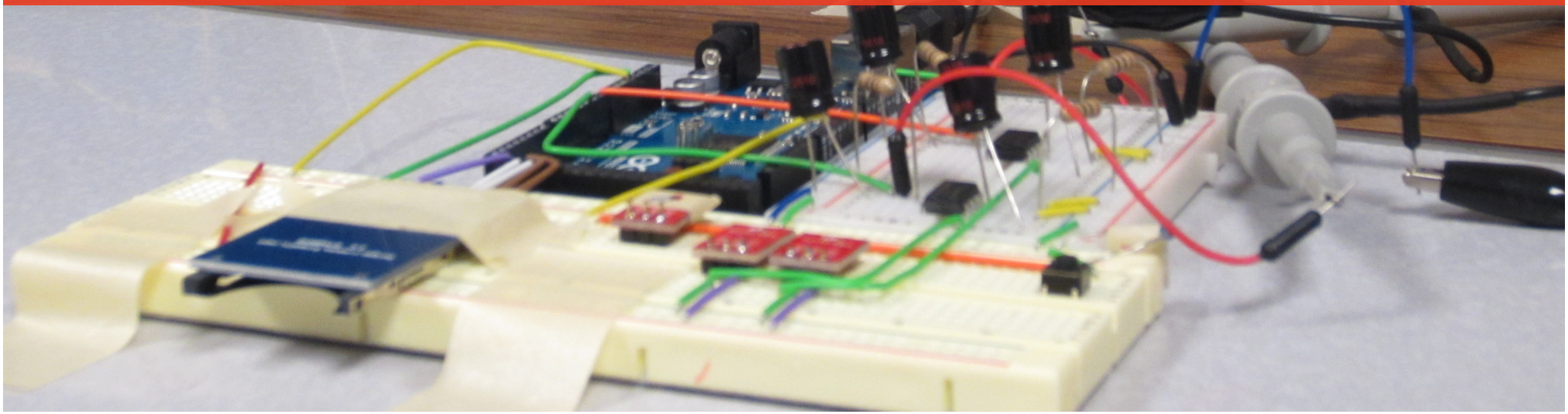


(bits-per-second, entry level versions)

Hardware front-end

Vibration recovery at the receiver

Transmitter side rate control



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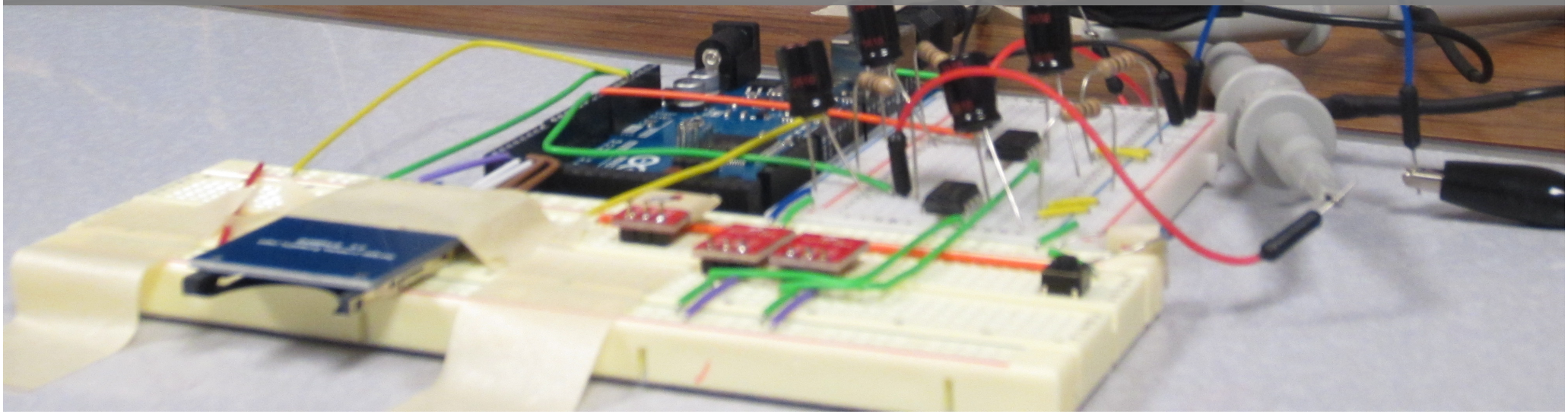
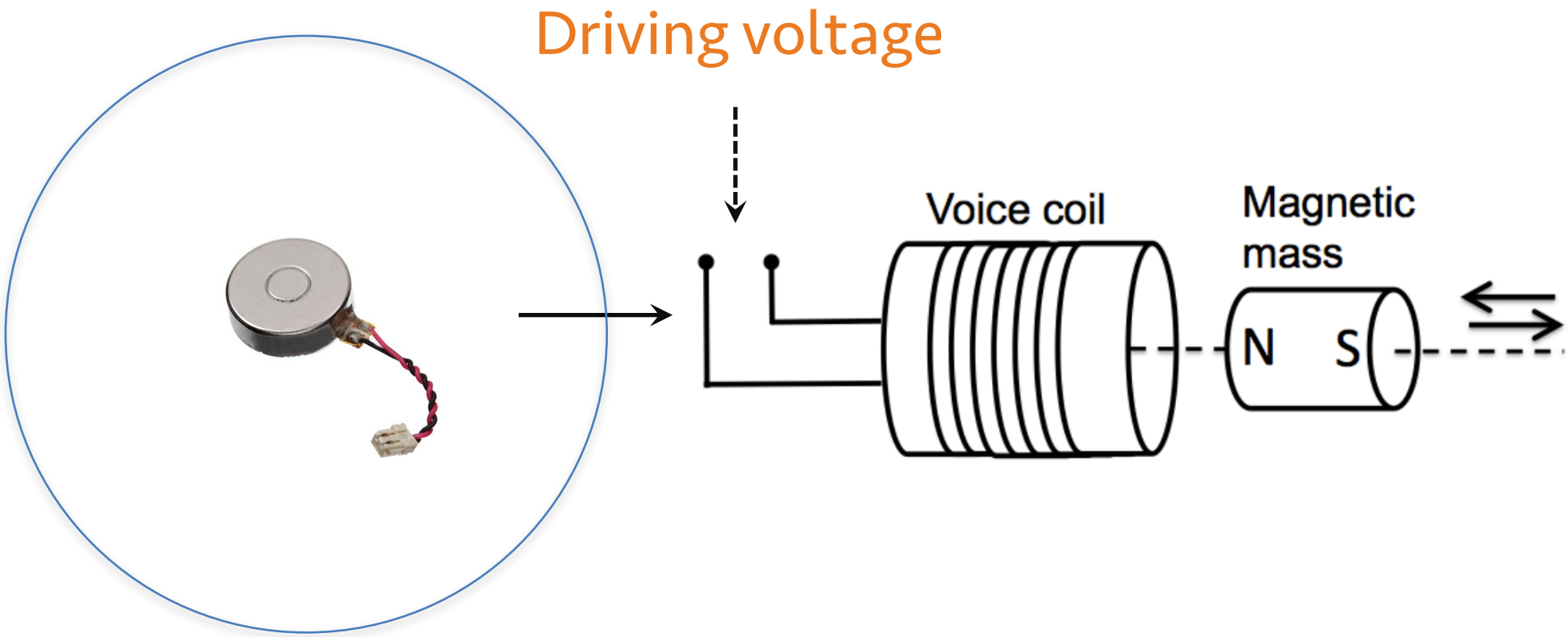


A better sensor for physical vibration
The transmitter:

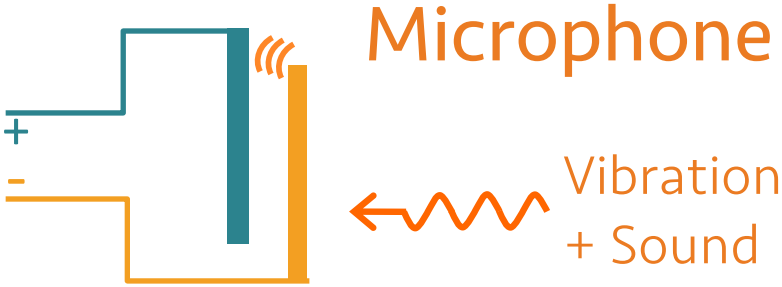


A better sensor for physical vibration

The receiver:

A better sensor for physical vibration

The receiver:

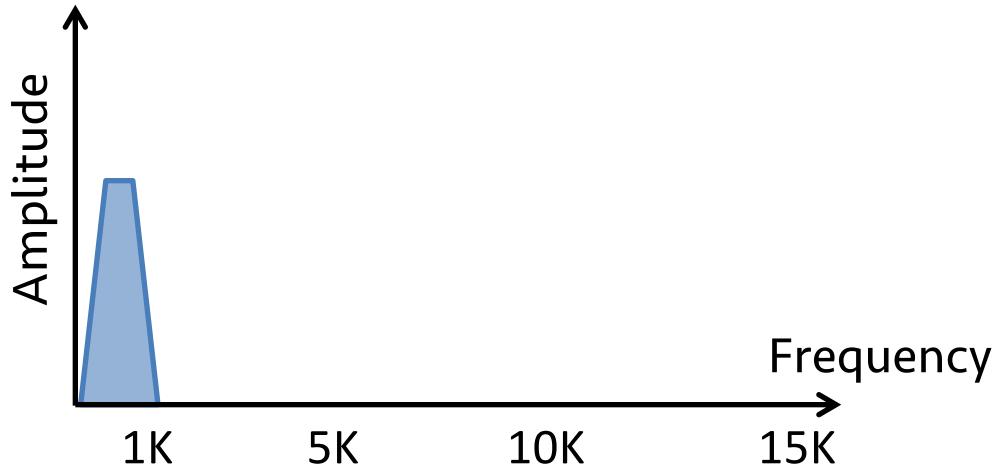


A better sensor for physical vibration

The receiver:

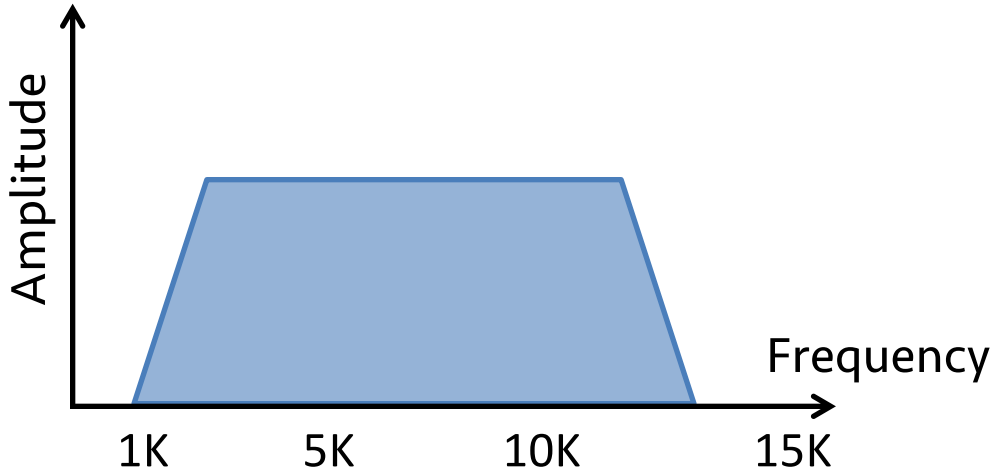
Accelerometer

Vibration



Microphone

Vibration
+ Sound

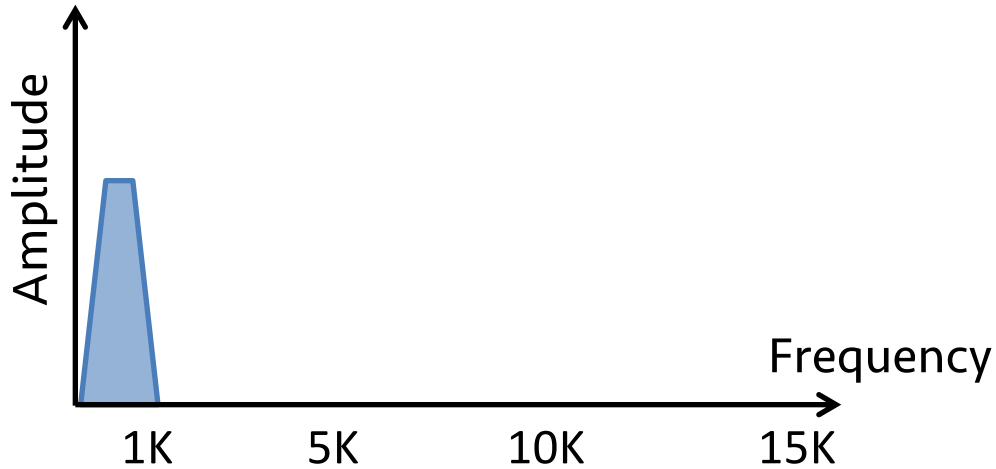


A better sensor for physical vibration

The receiver:

Accelerometer

Vibration



Microphone

Vibration
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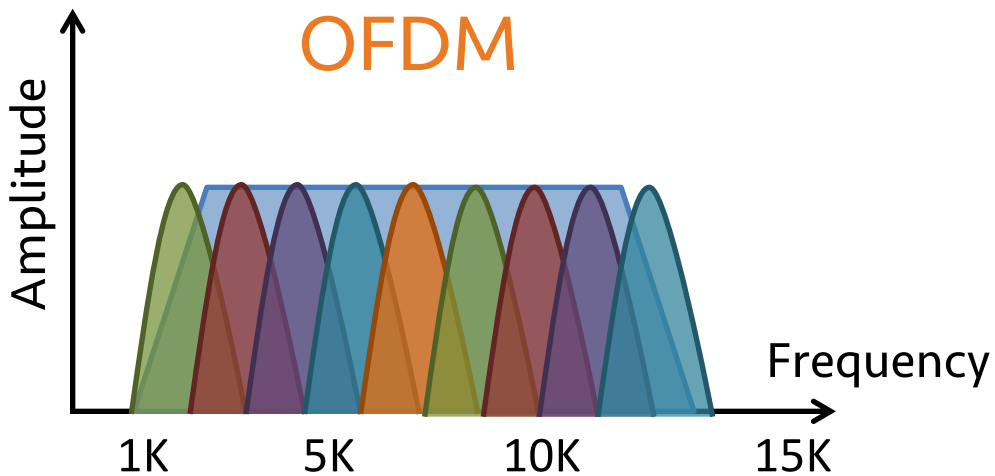


A better sensor for physical vibration
The receiver:

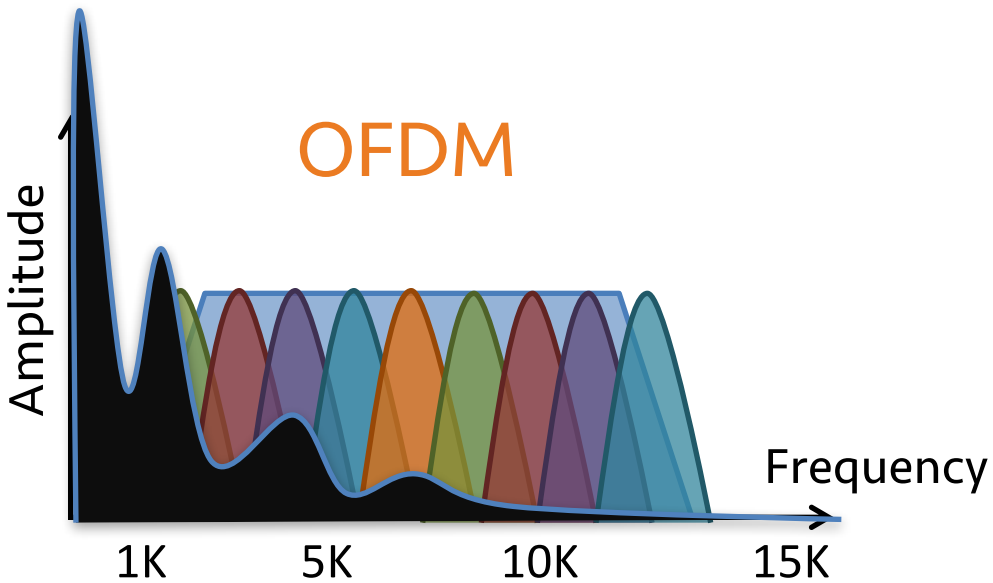
But wait...

A better sensor for physical vibration
The receiver:

Ambient sound

Microphone

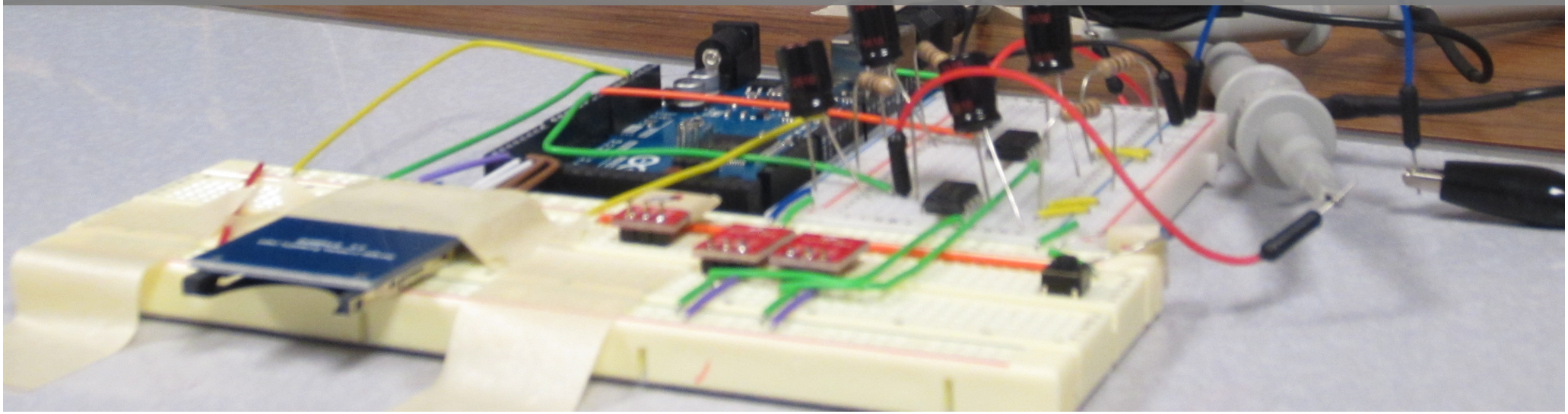
Vibration
+ Sound



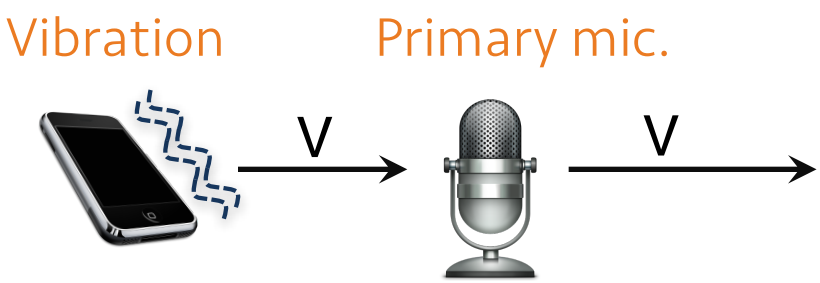
Hardware front-end

Vibration recovery at the receiver

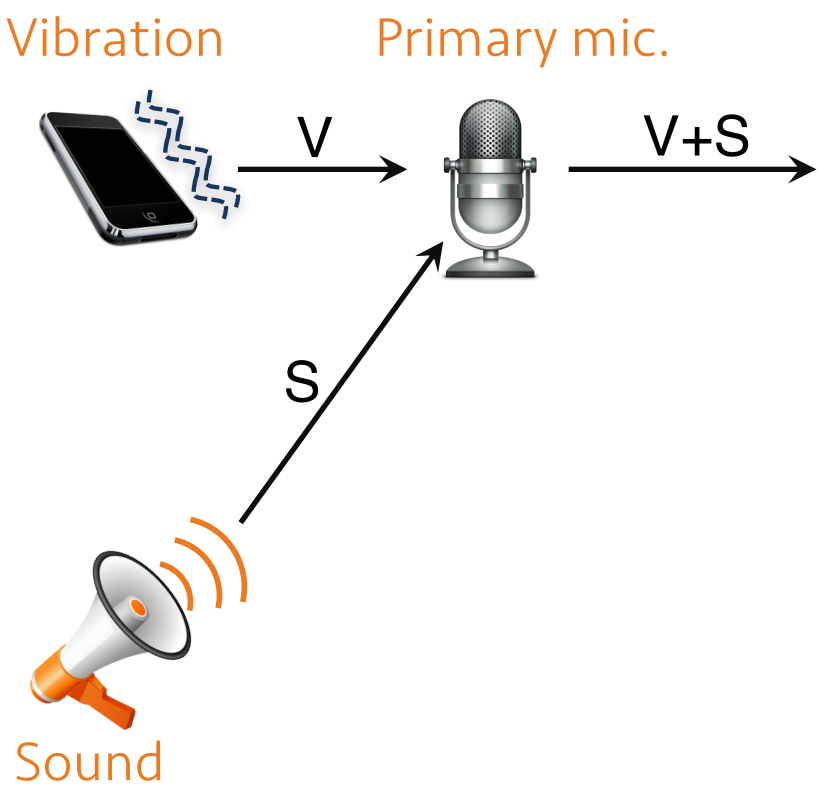
Transmitter side rate control



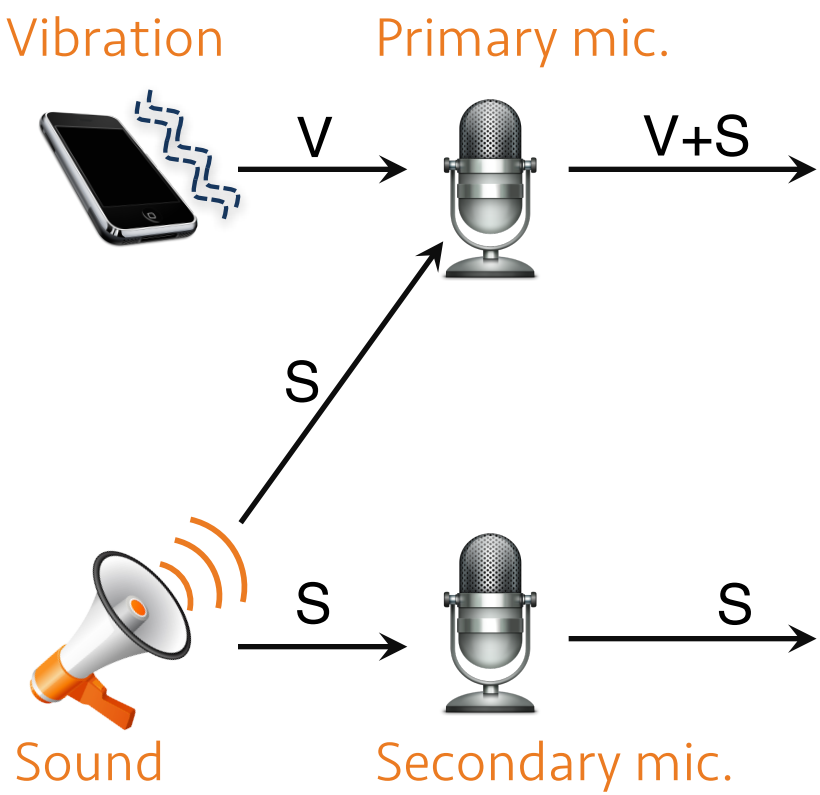
Vibration recovery at receiver



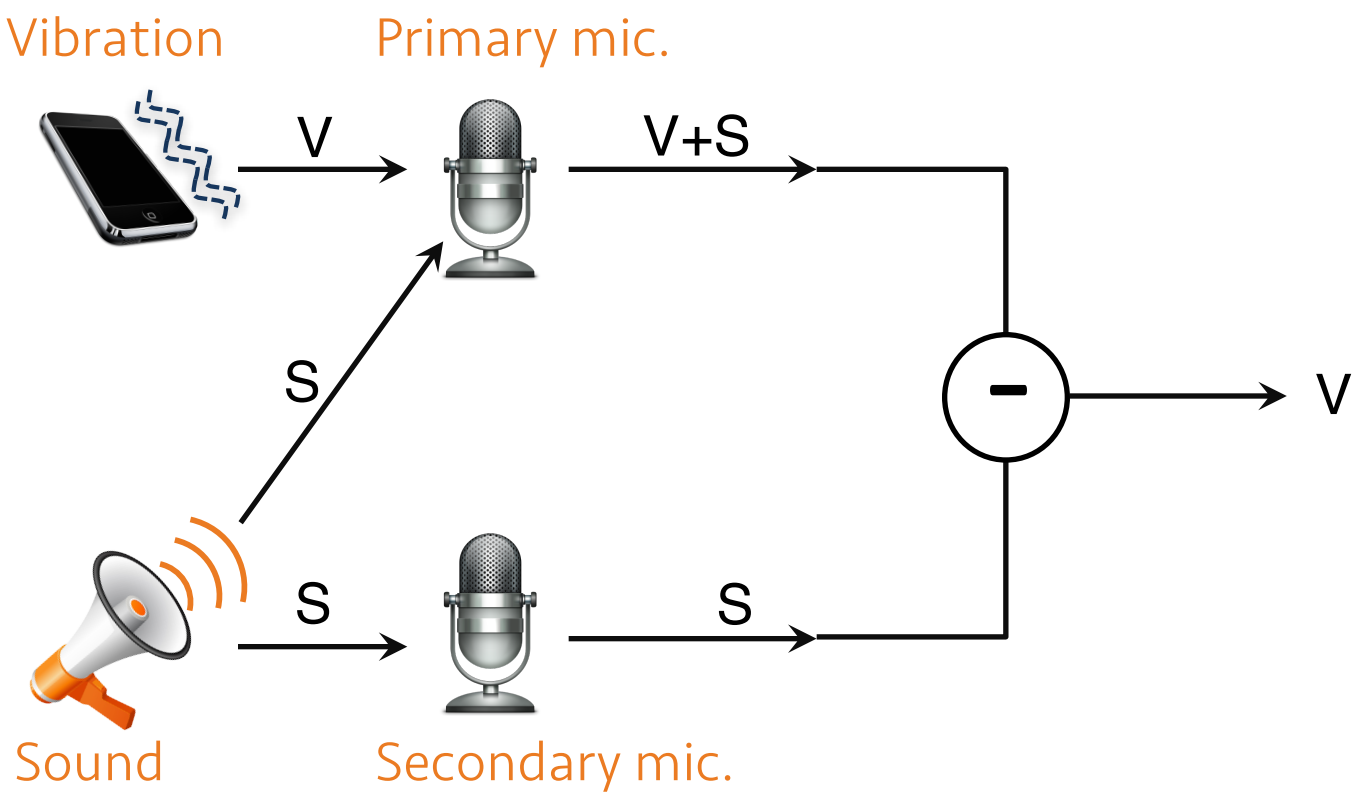
Vibration recovery at receiver



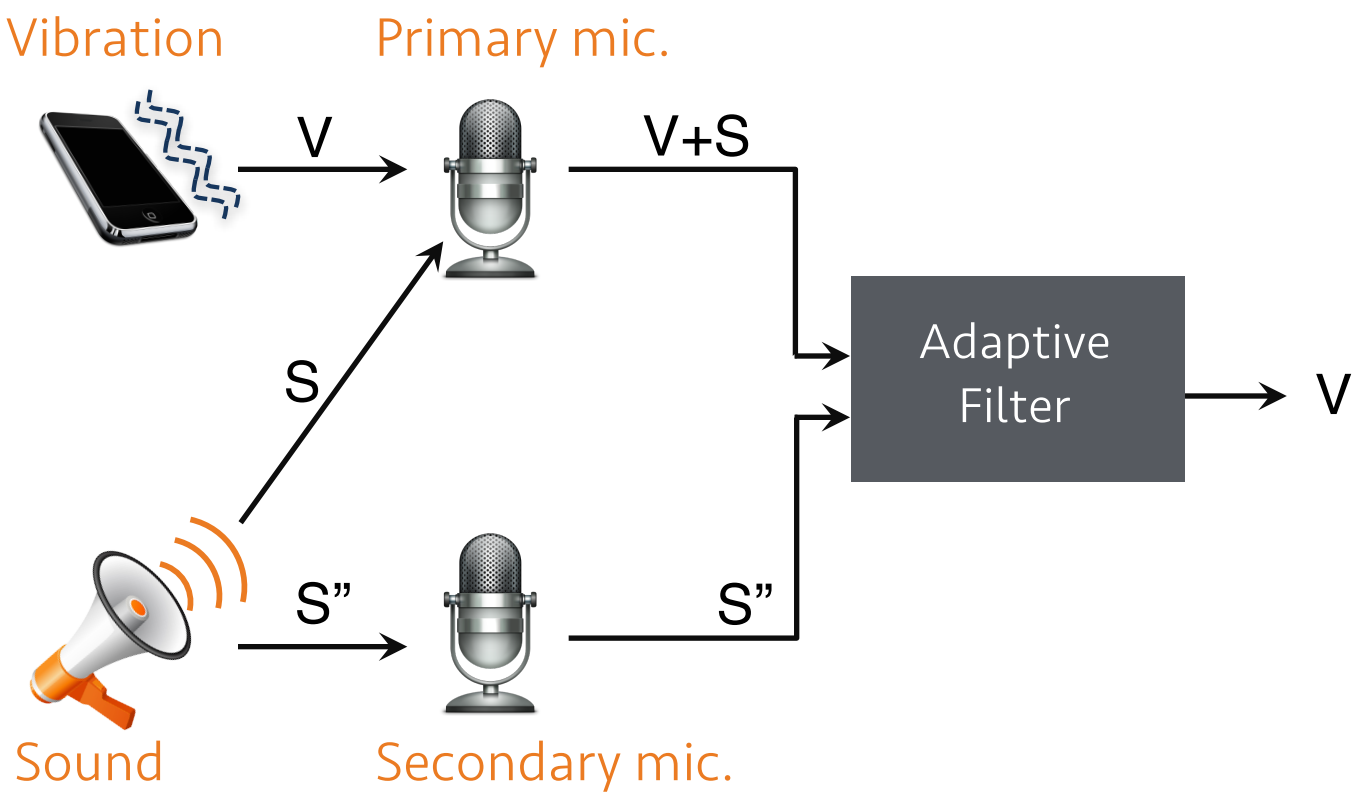
Vibration recovery at receiver



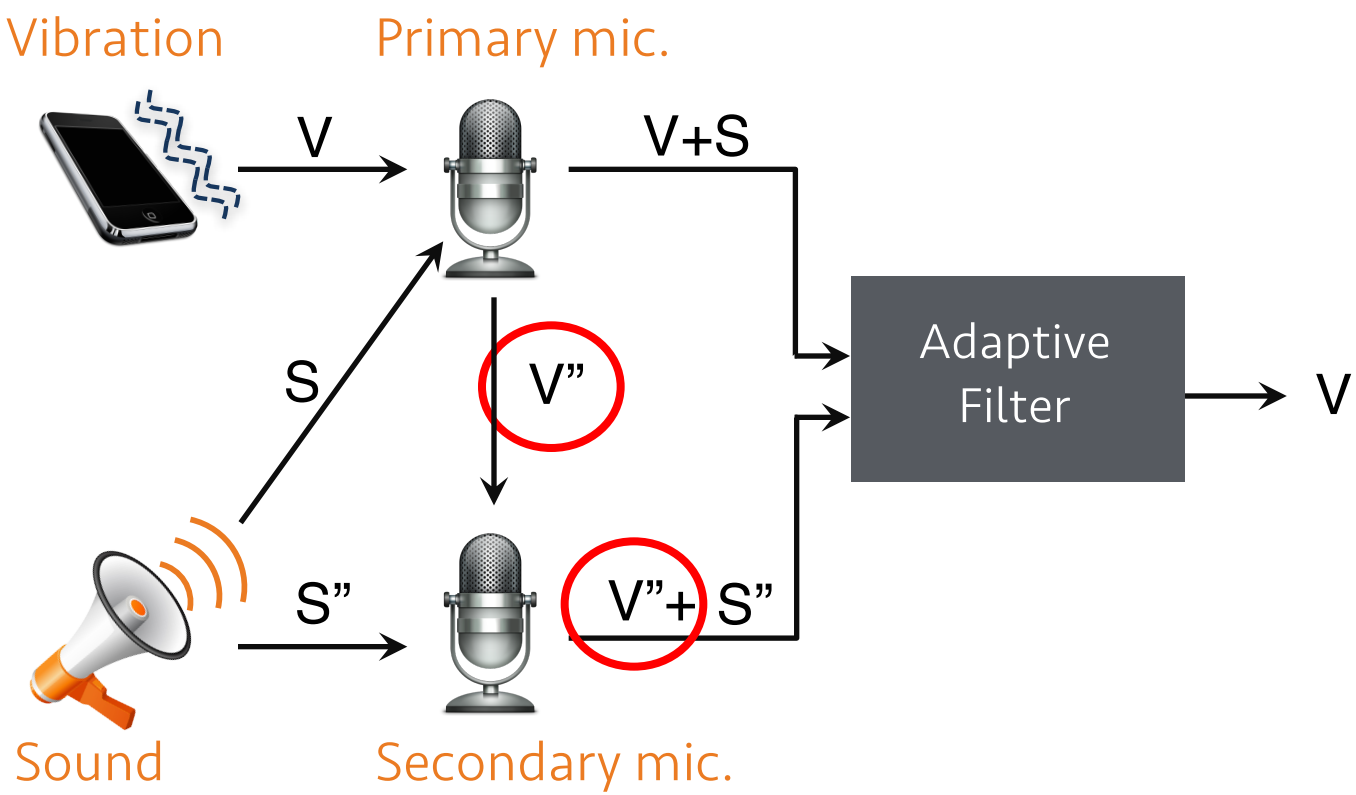
Vibration recovery at receiver



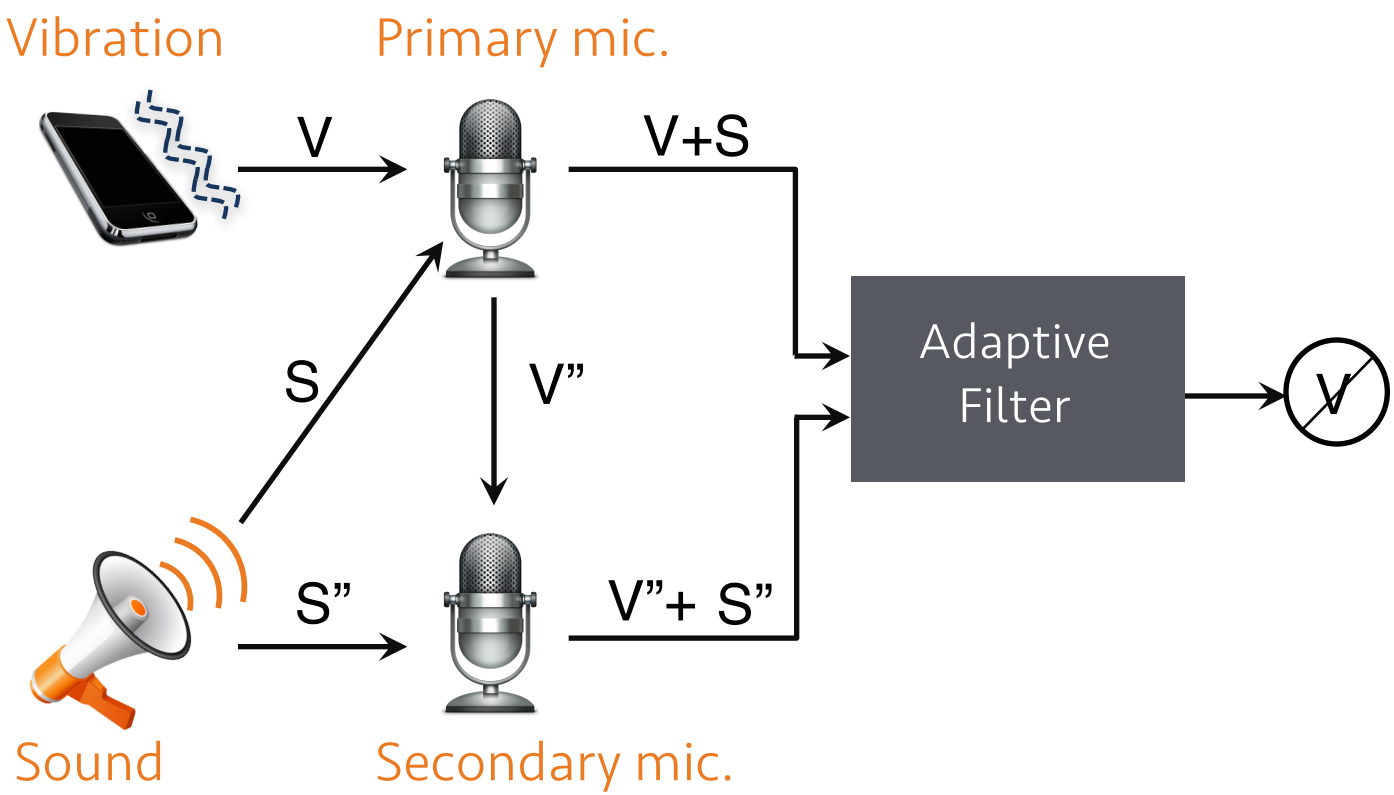
Vibration recovery at receiver



Vibration recovery at receiver

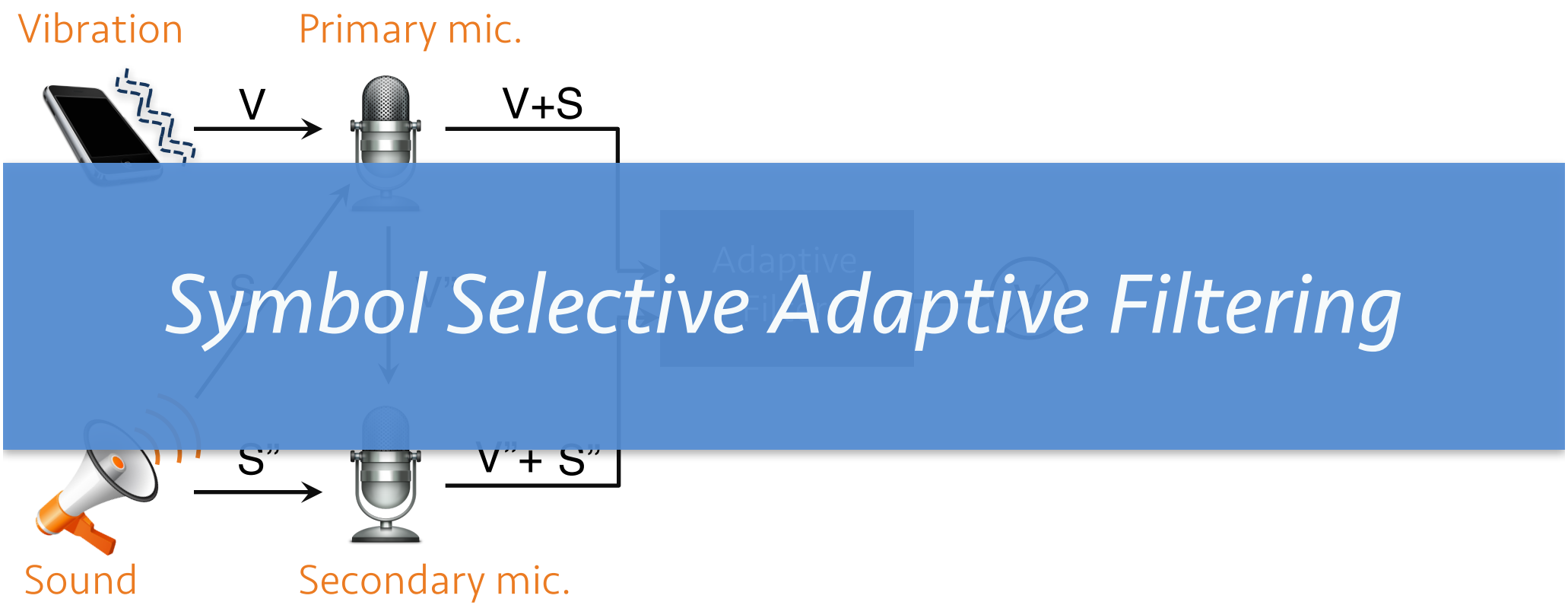


Vibration recovery at receiver



Signal sources are correlated

Vibration recovery at receiver

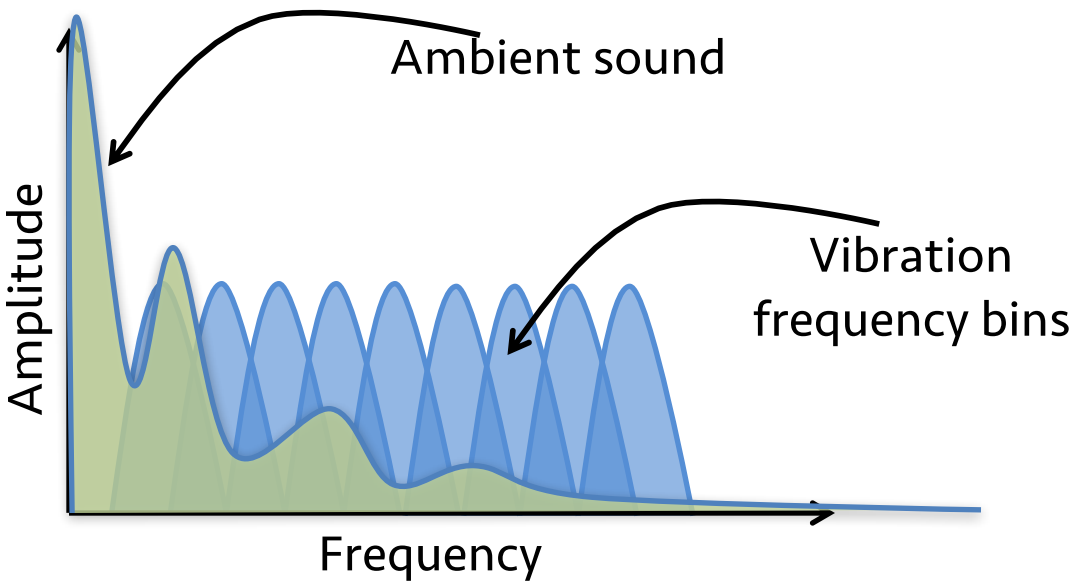


Symbol Selective Adaptive Filtering

Signal sources are correlated

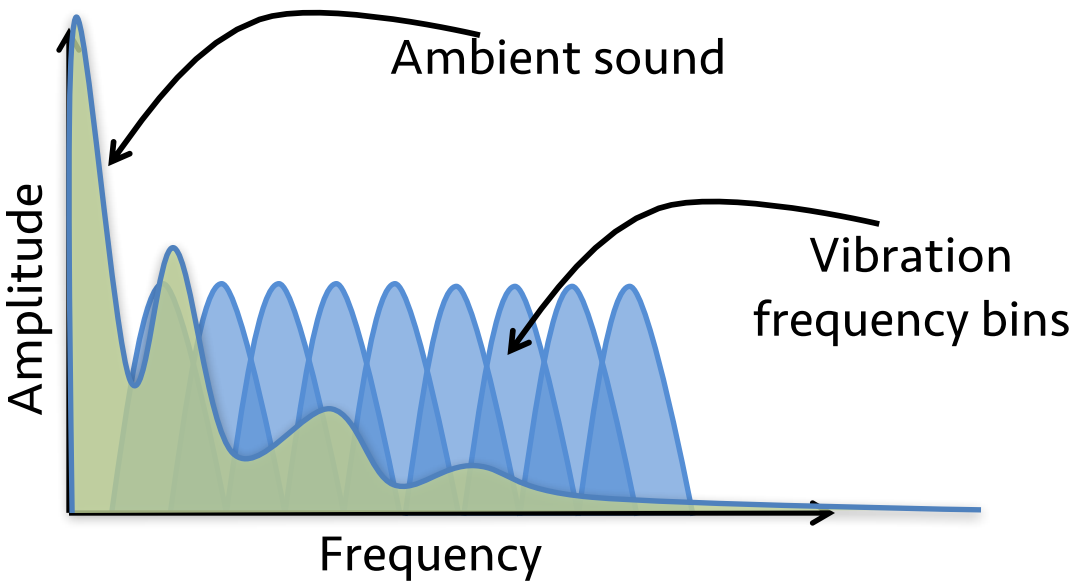
Vibration recovery at receiver

Noise is sparse in frequency

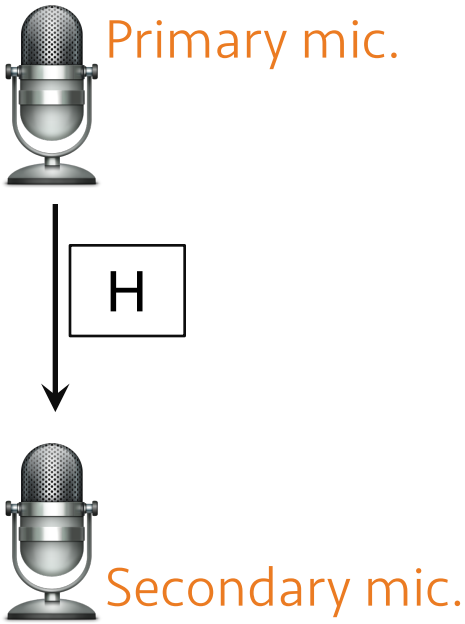


Vibration recovery at receiver

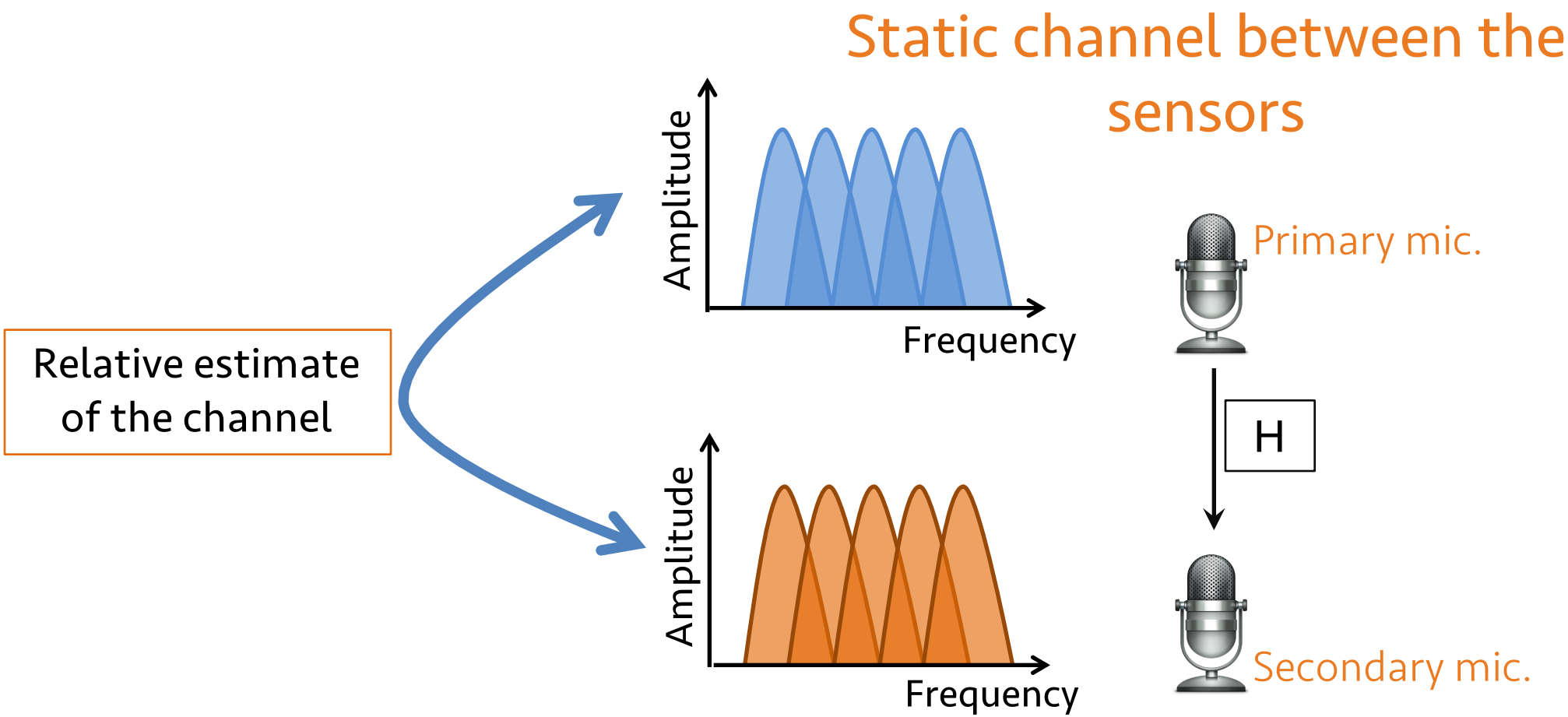
Noise is sparse in frequency



Static channel between the sensors



Vibration recovery at receiver



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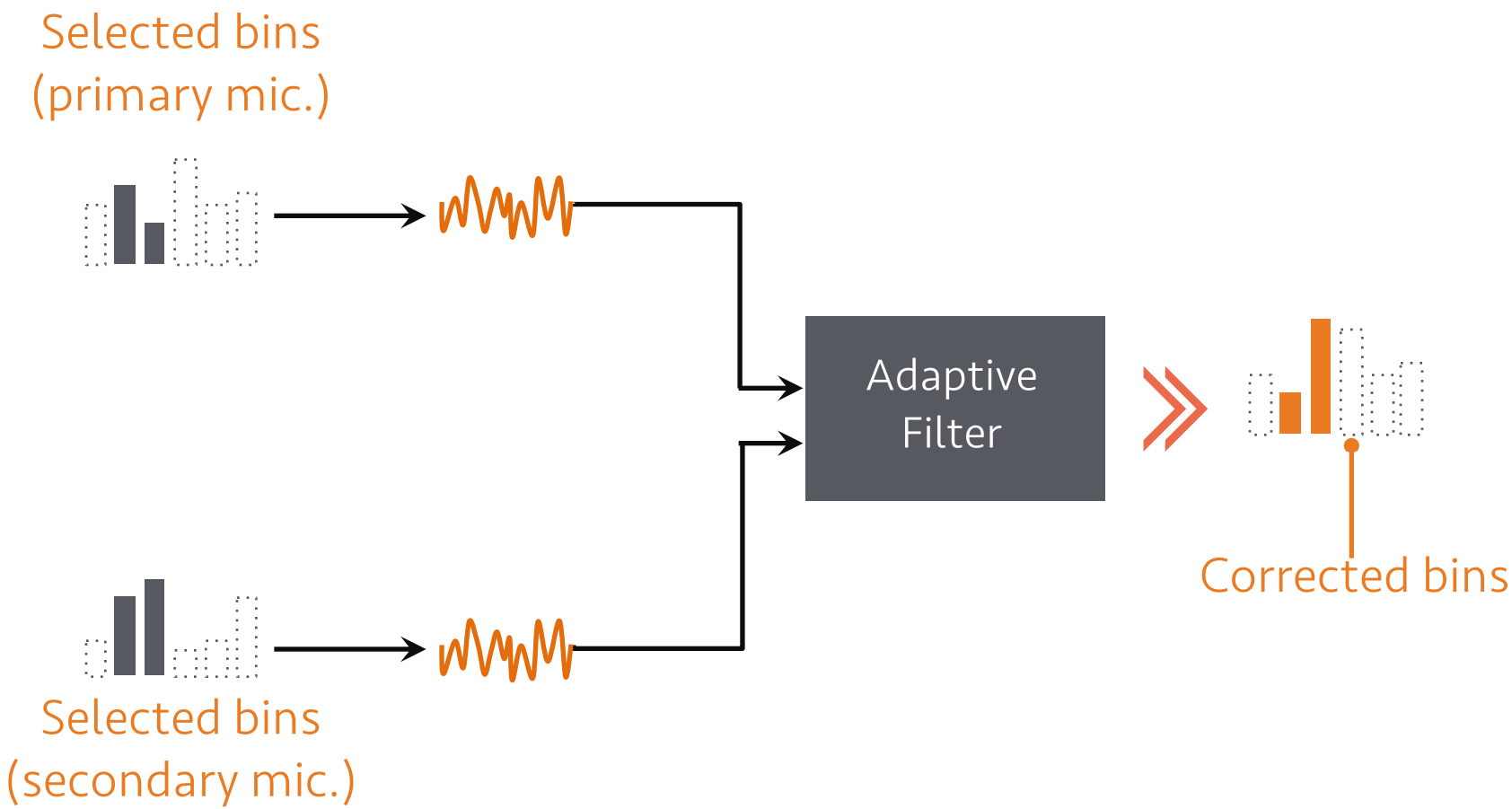
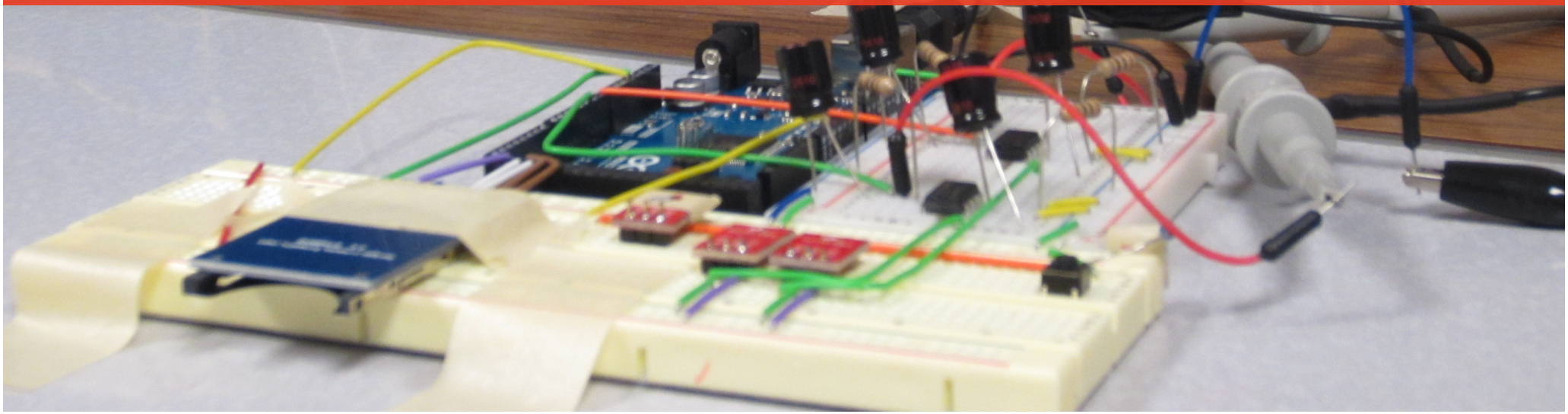


Hardware front-end

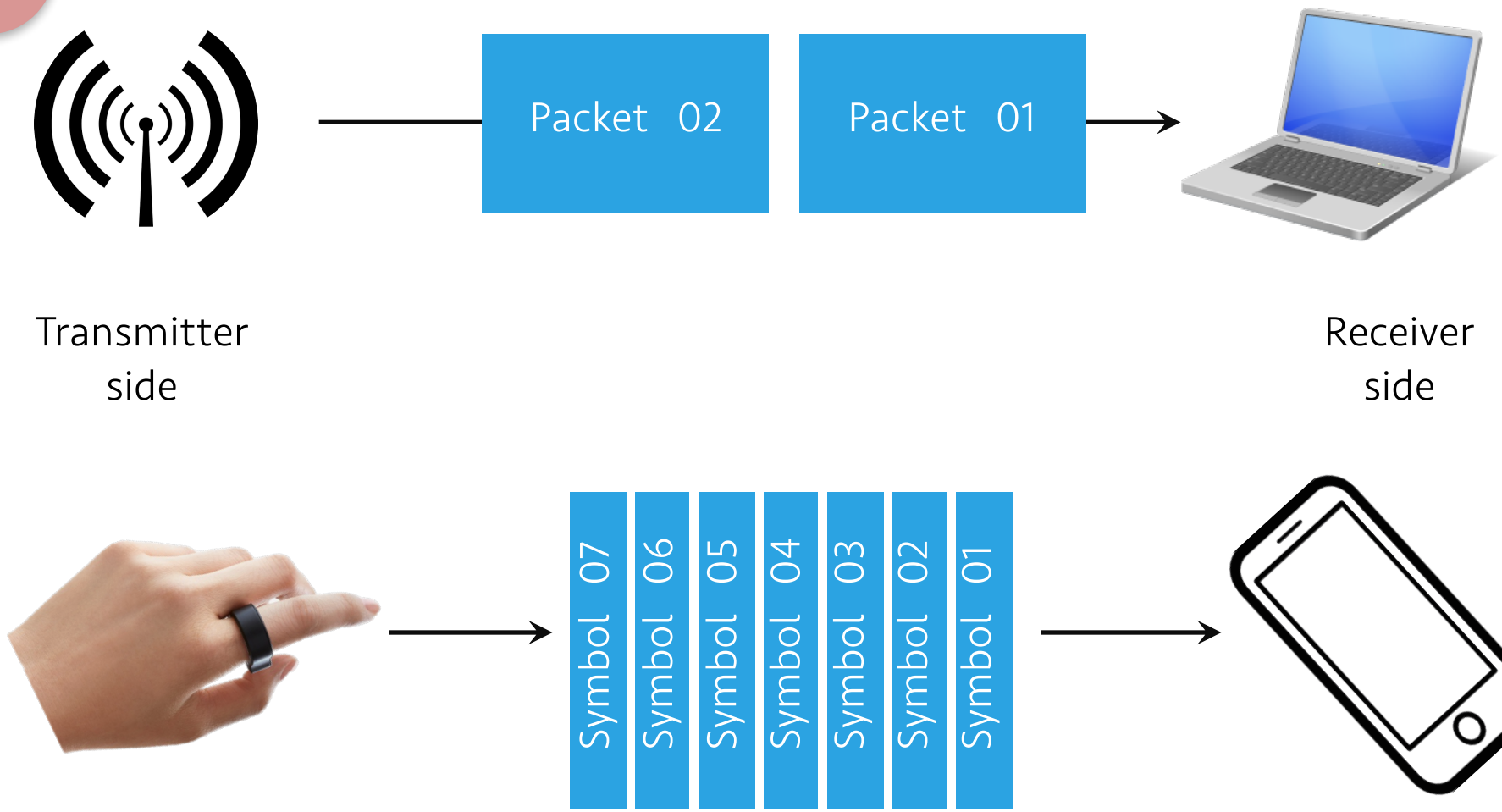
Vibration recovery at the receiver

Transmitter side rate control

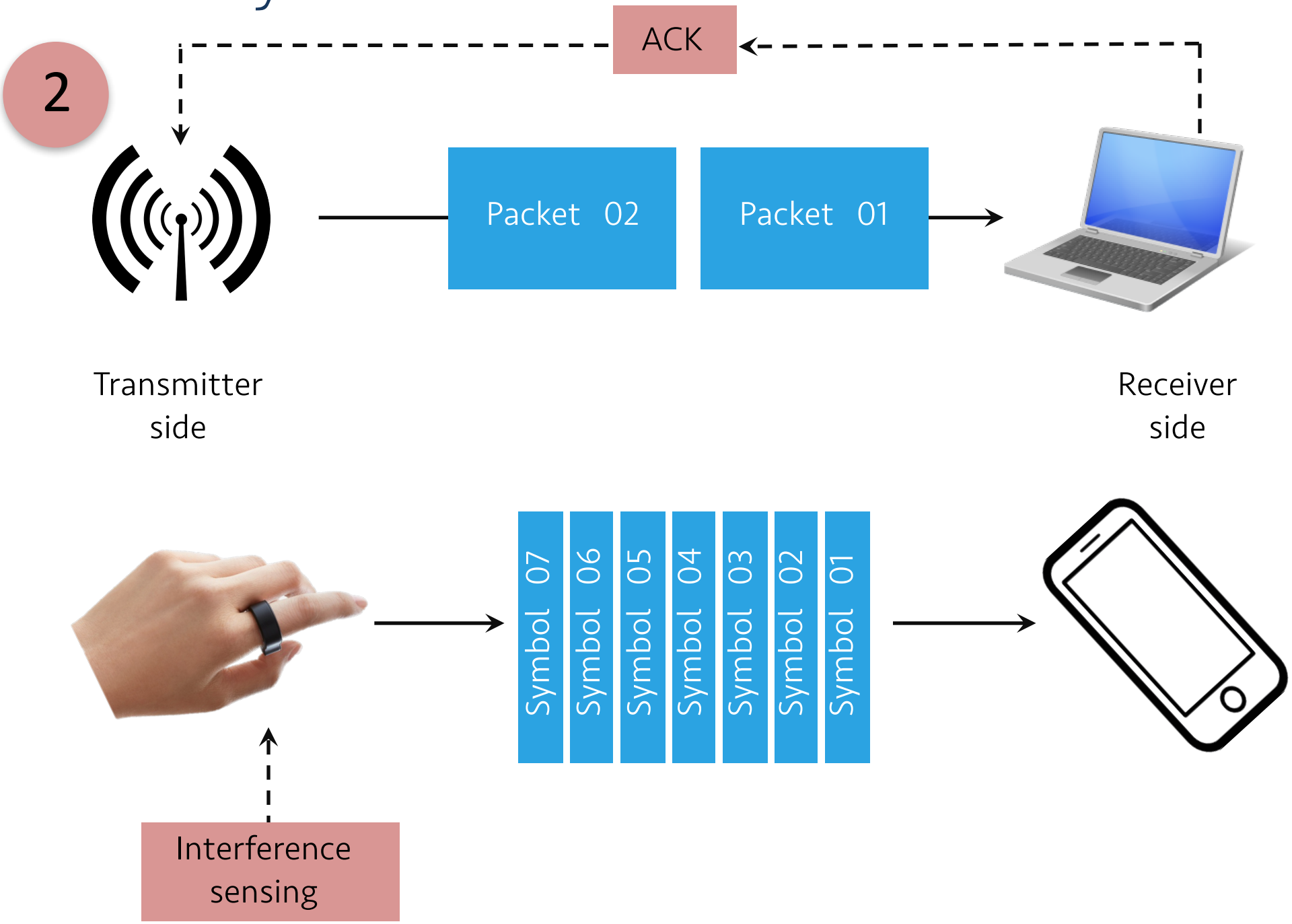


MAC layer rate control

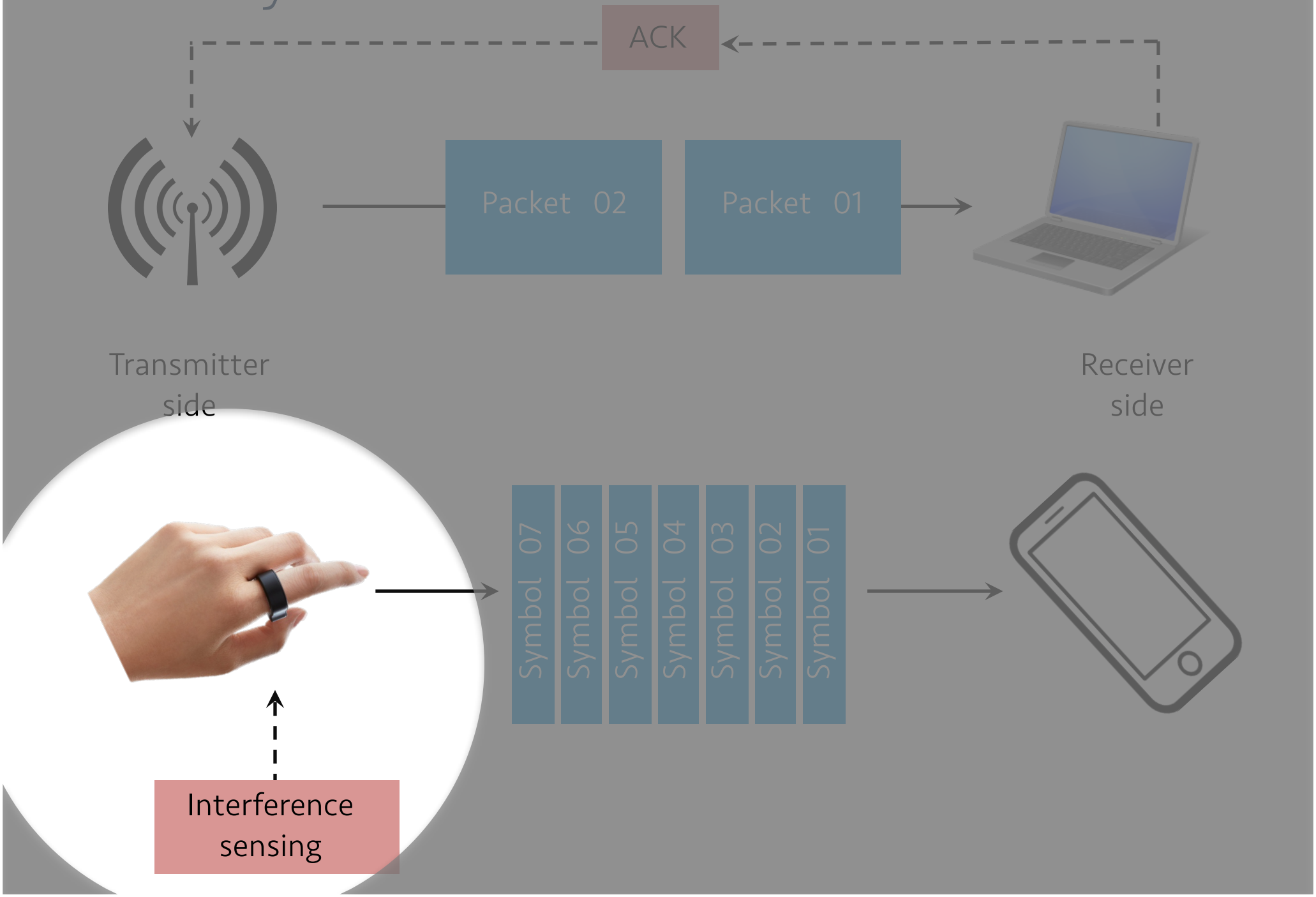
1



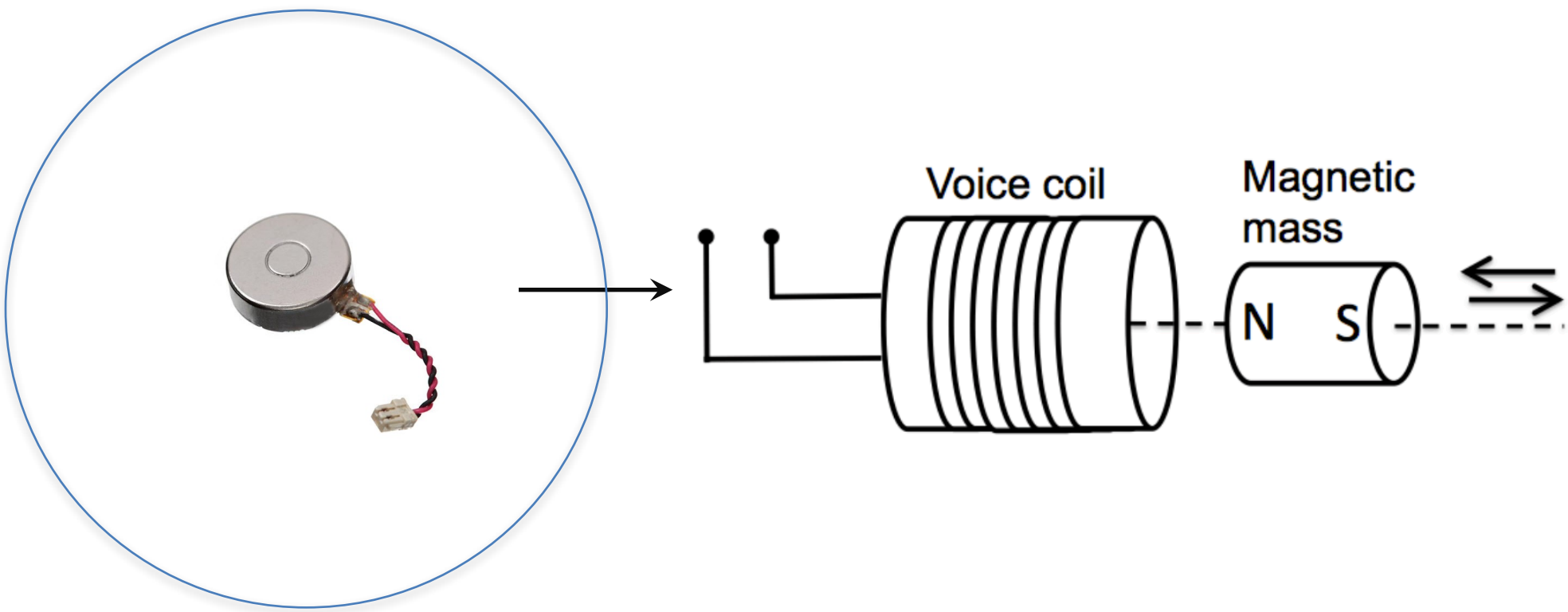
MAC layer rate control



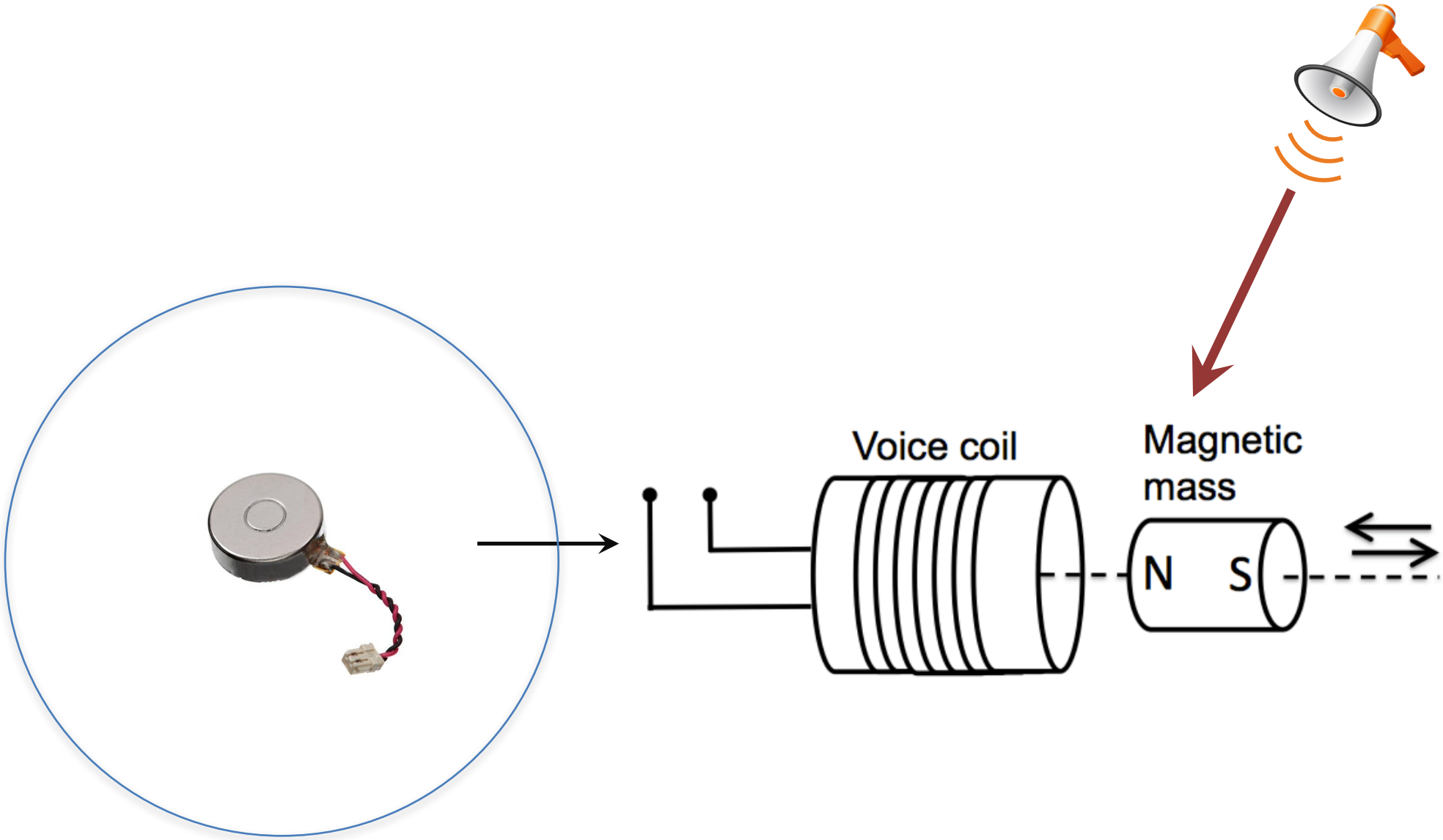
MAC layer rate control



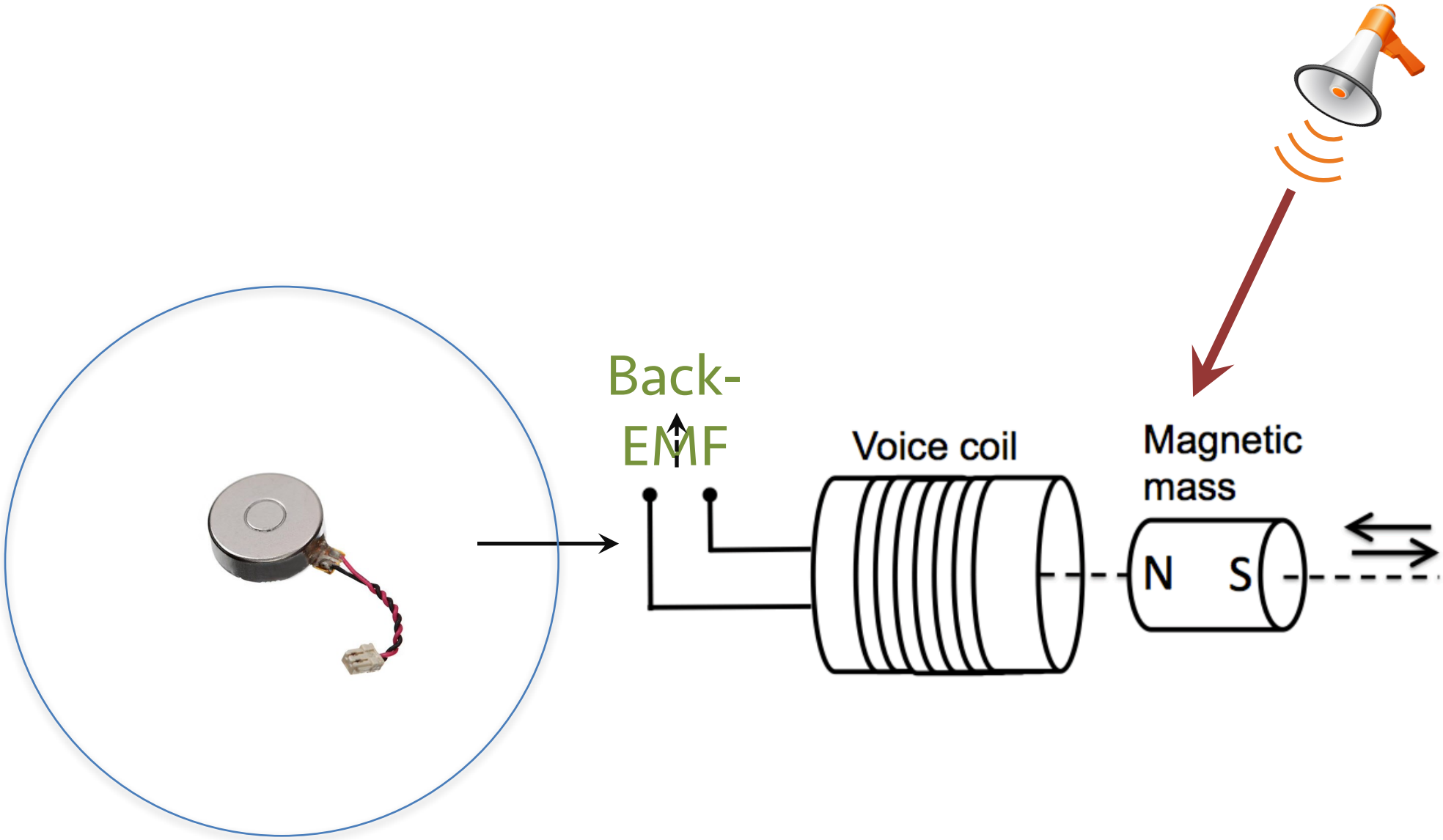
MAC layer rate control



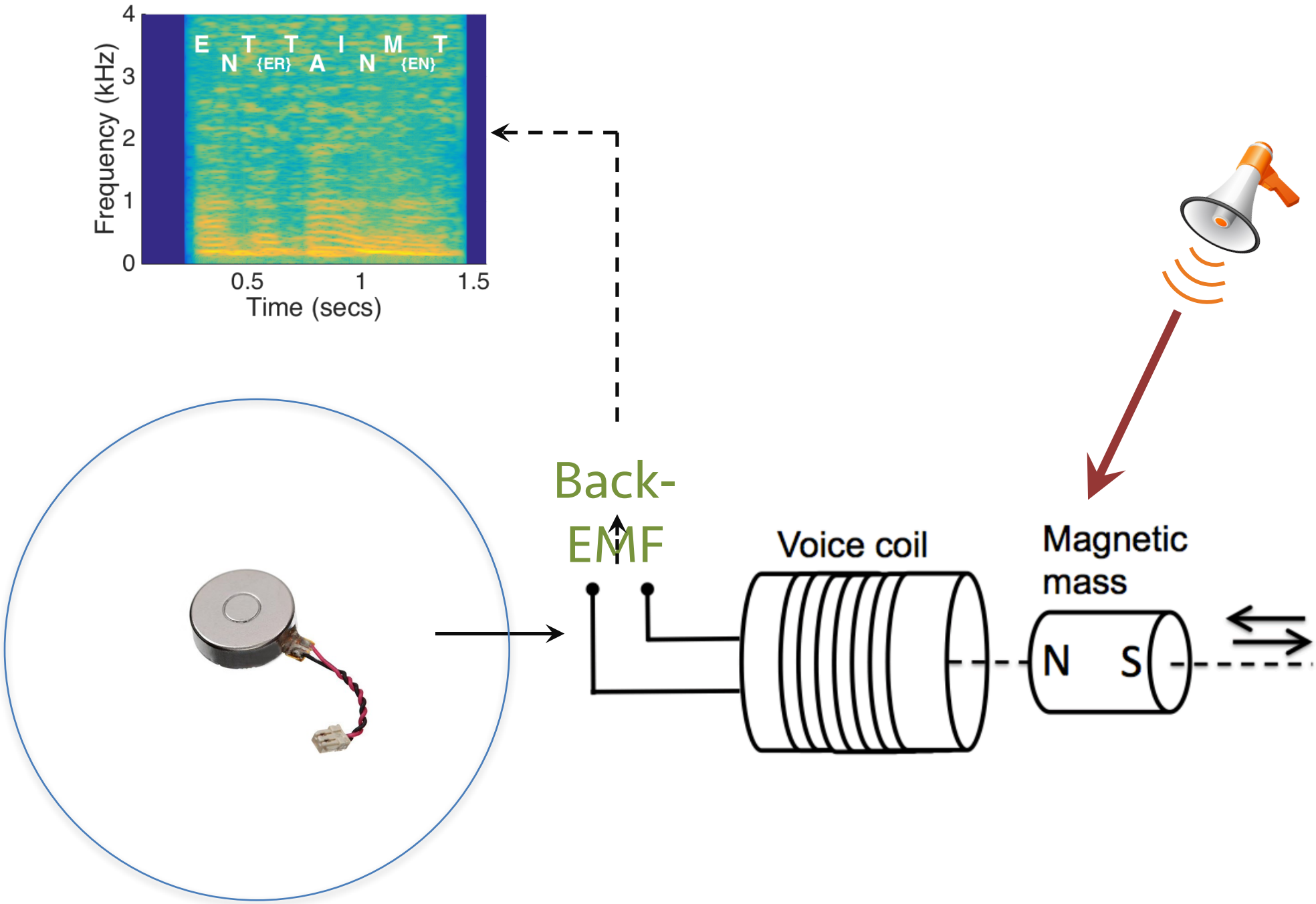
MAC layer rate control



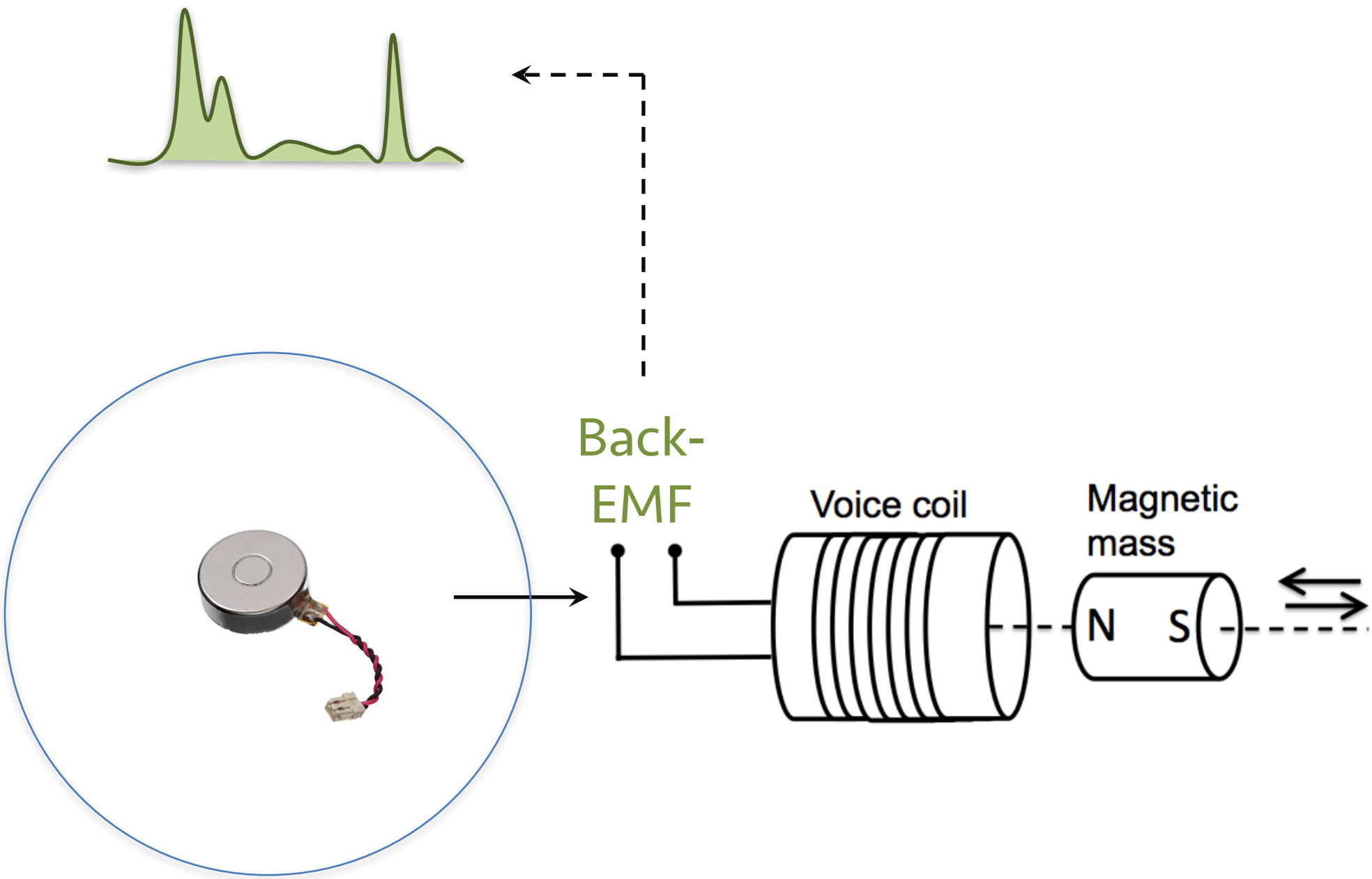
MAC layer rate control



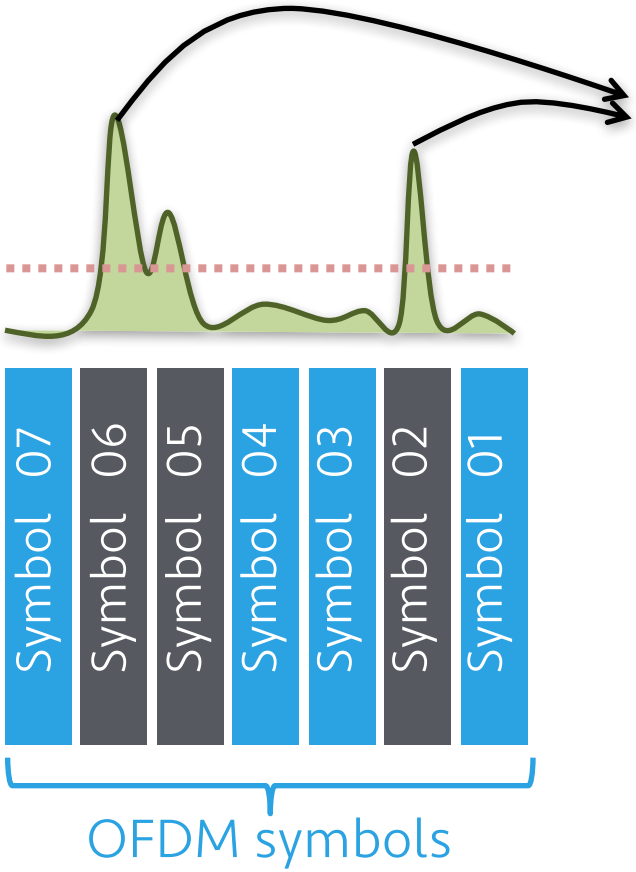
MAC layer rate control



MAC layer rate control

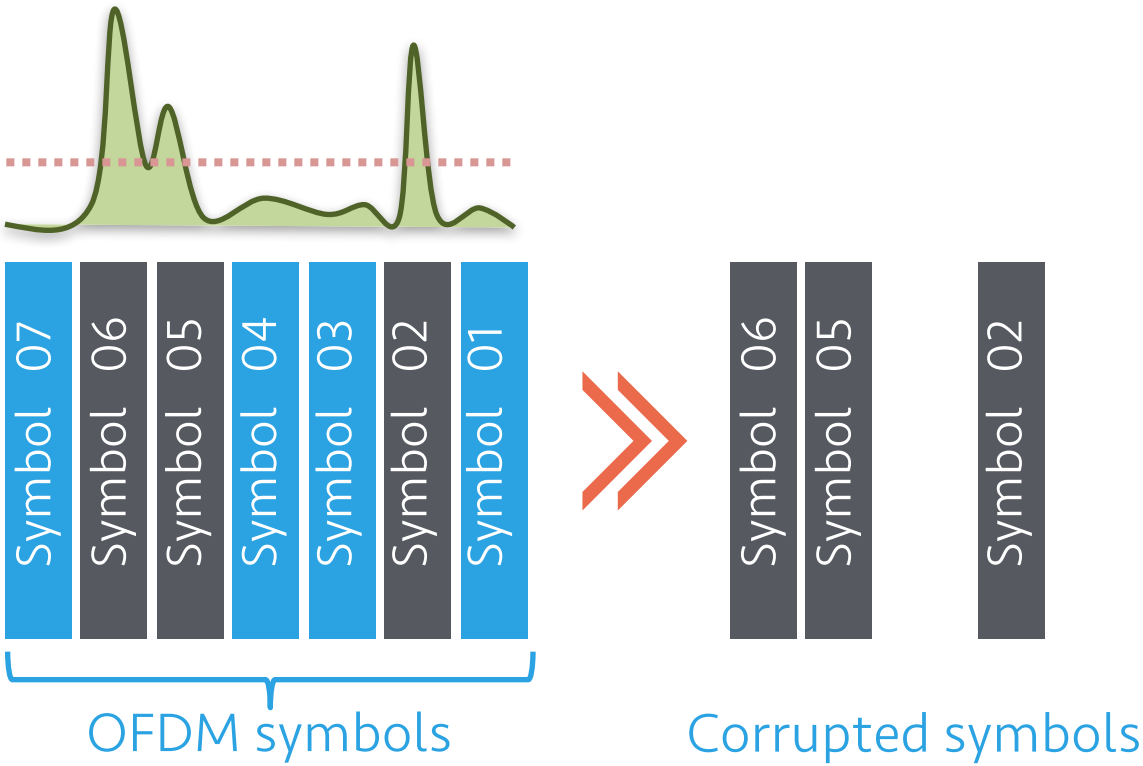


MAC layer rate control

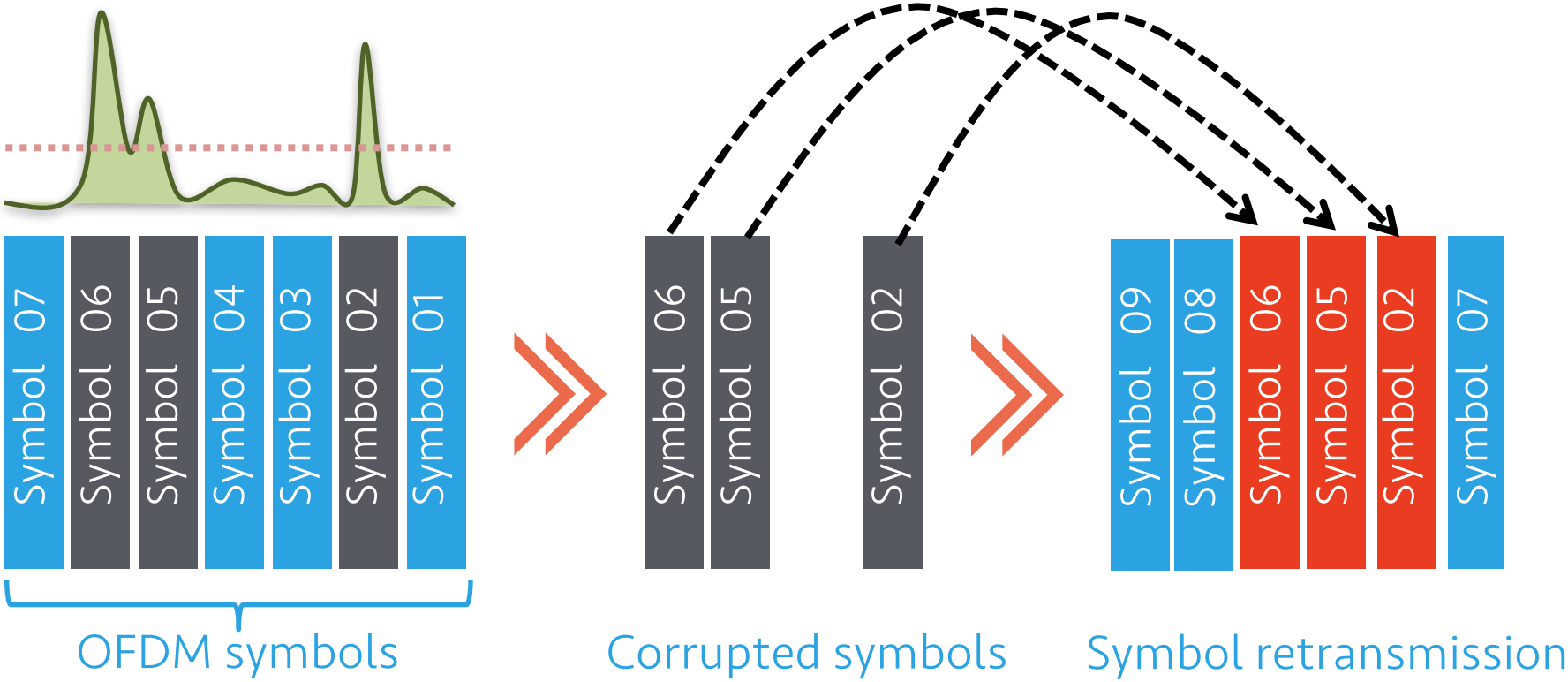


Low “Signal to Interference and Noise Ratio” (SINR)

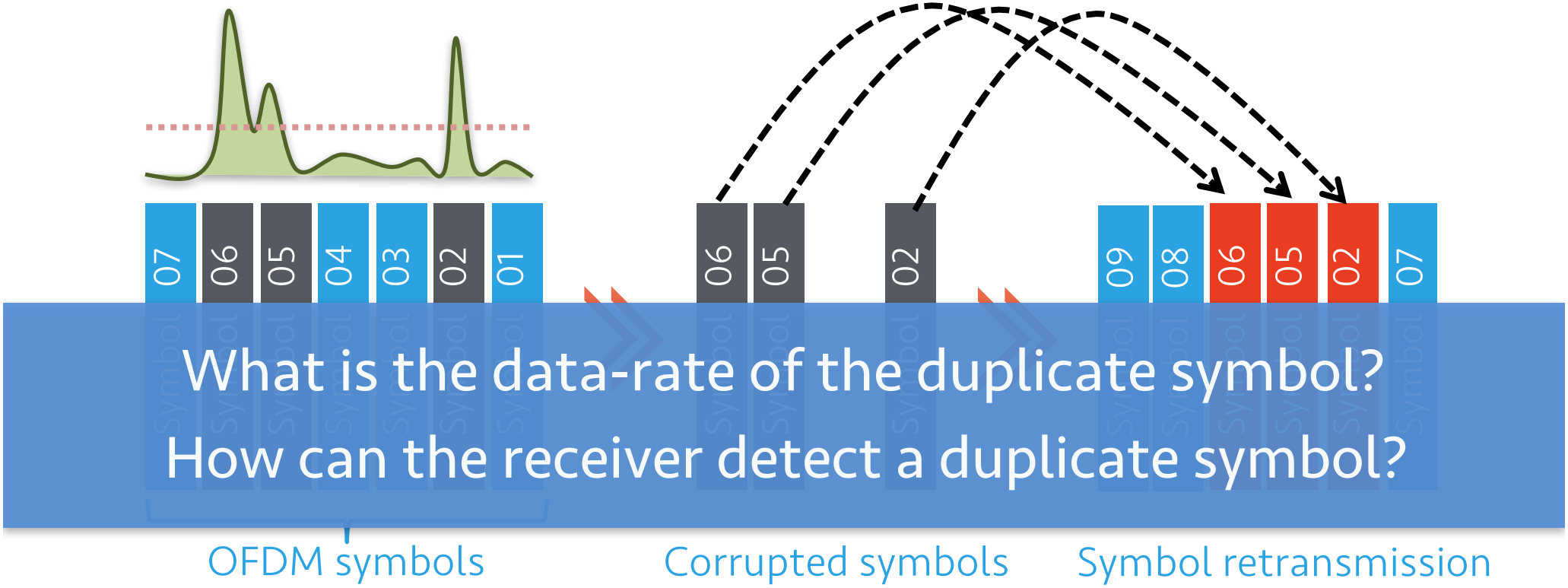
MAC layer rate control



MAC layer rate control



MAC layer rate control

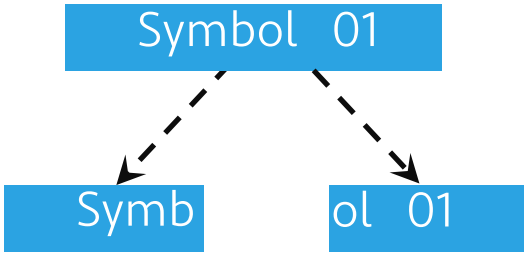


What is the data-rate of the duplicate symbol?

How can the receiver detect a duplicate symbol?

MAC layer rate control

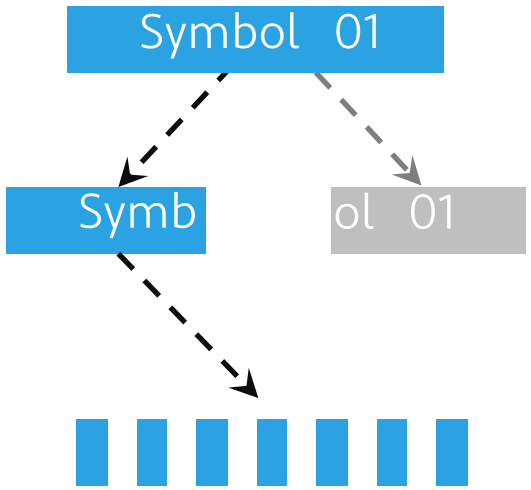
Half of the symbol per retransmission



Doubles the energy per bit

MAC layer rate control

Half of the symbol per retransmission



Doubles per bit energy

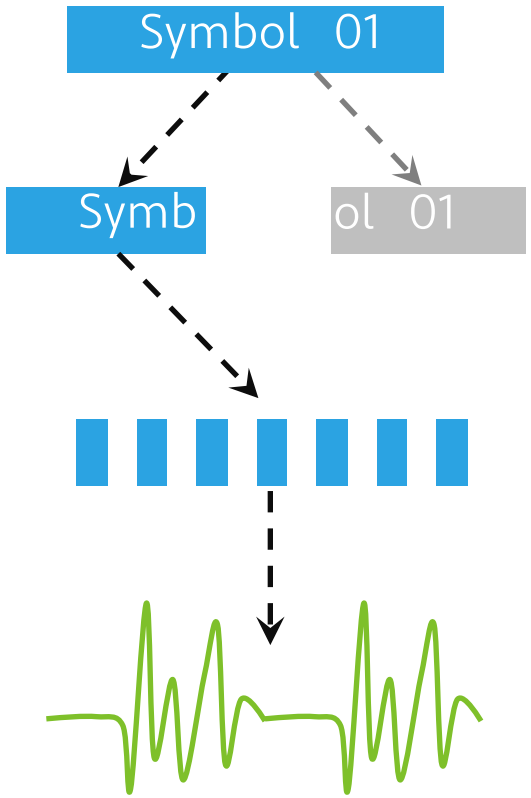
Data in alternate frequency bins

MAC layer rate control

Half of the symbol per retransmission

Data in alternate frequency bins

Identical halves in the time domain signal



Doubles per bit energy

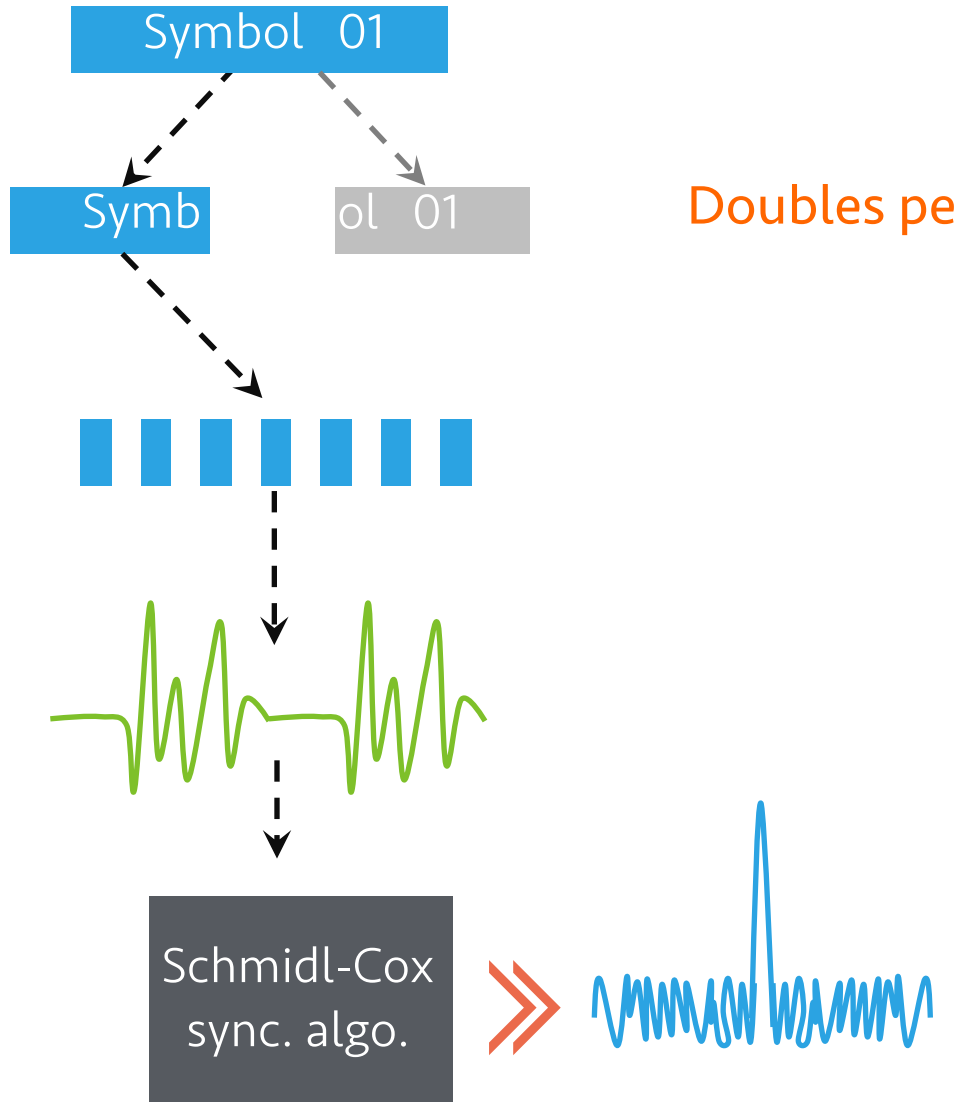
MAC layer rate control

Half of the symbol per retransmission

Data in alternate frequency bins

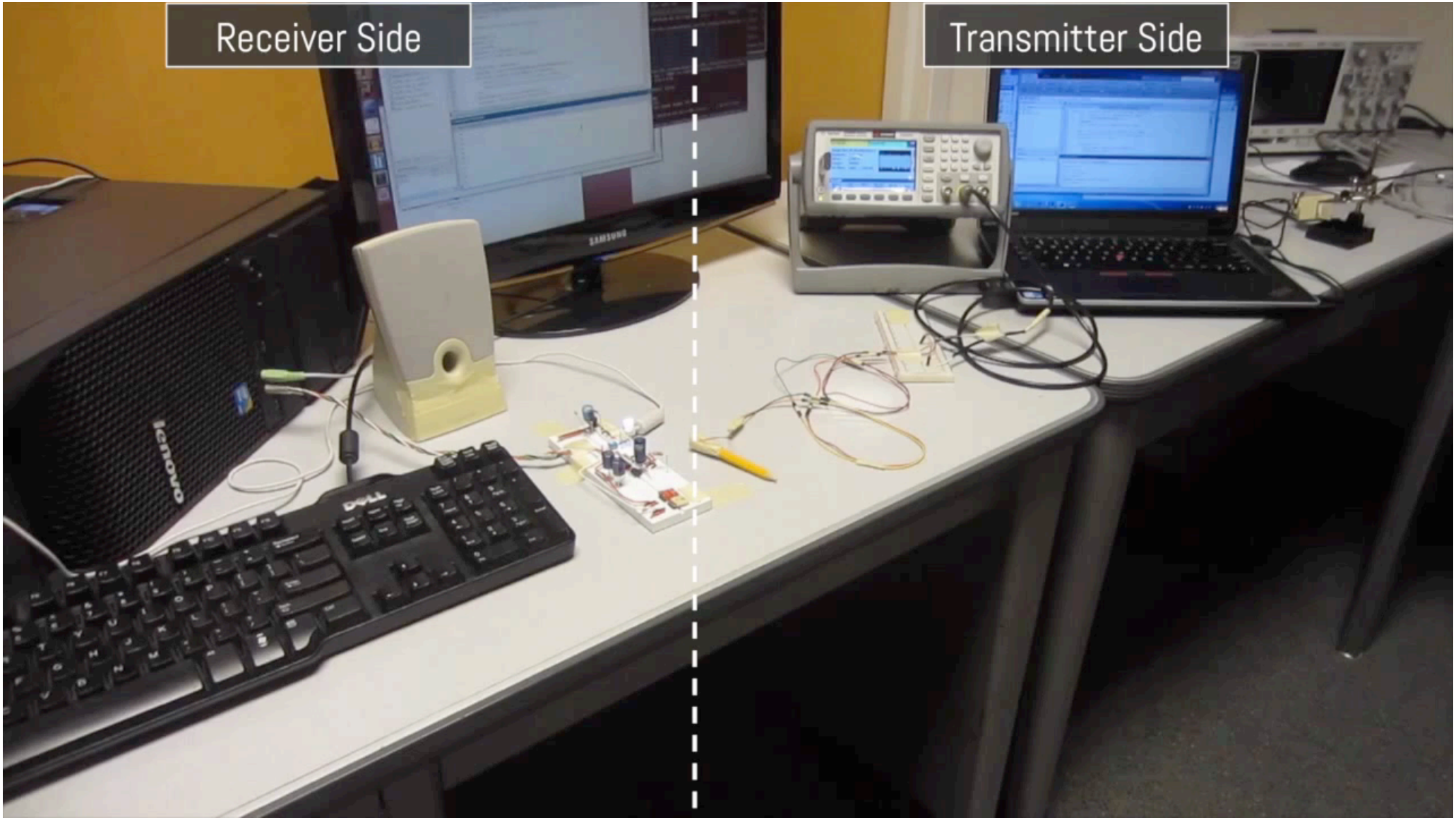
Identical halves in the time domain signal

Algorithm detects this special symbol at the receiver

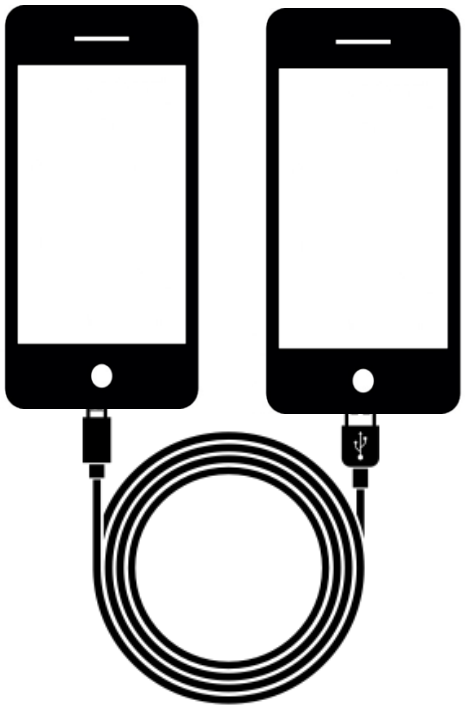


Doubles per bit energy

Demo



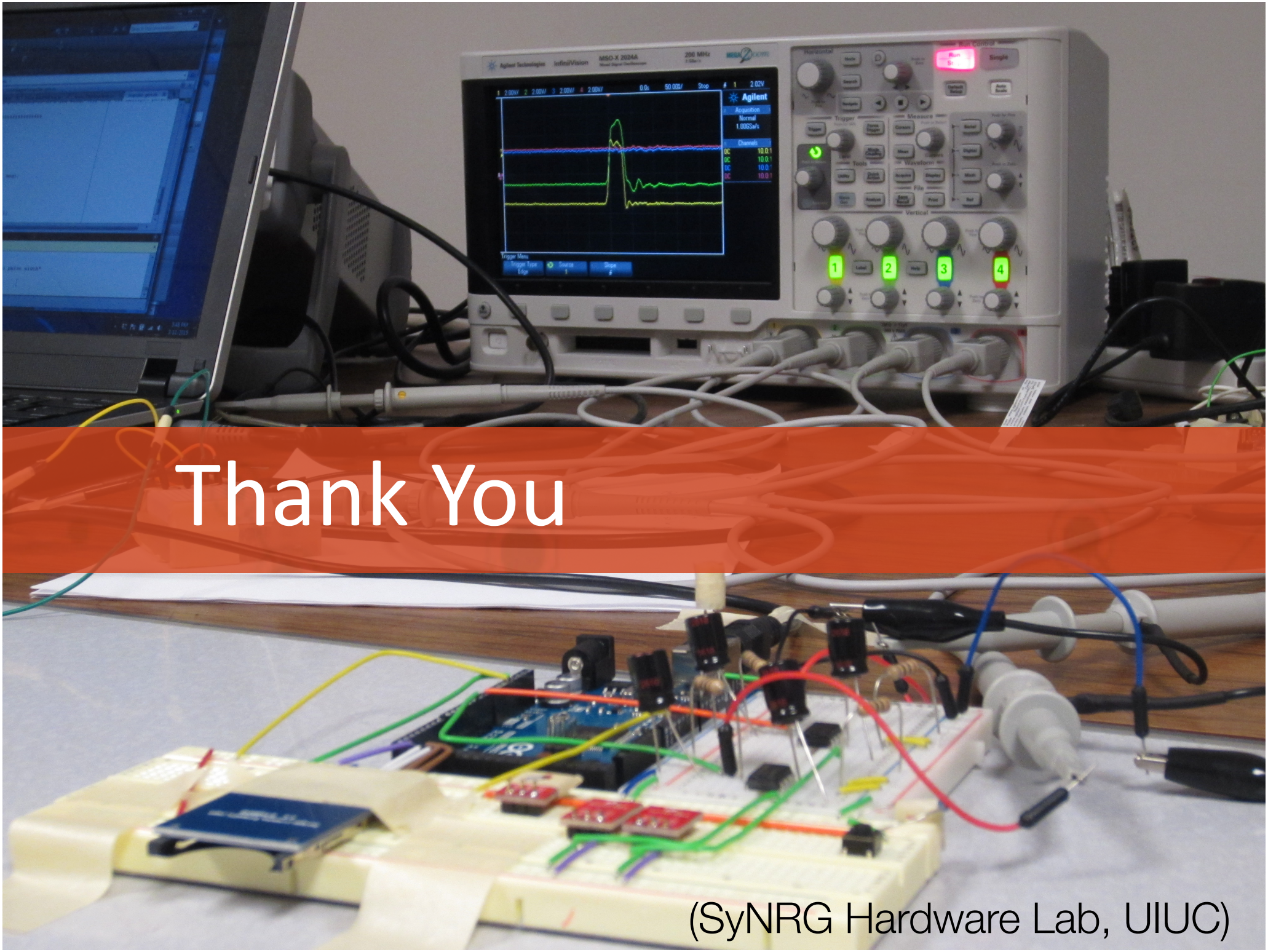
Applications



Vibrations do not **tether**

Vibrations do not **broadcast**

Vibratory communication


Thank You
(SyNRG Hardware Lab, UIUC)