

# Bandwidth

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# Final paper proposal

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- Final ~10 page paper
- Over next week:
  - Pick a topic
  - Find initial research sources
  - Write a proposal

# Types of paper

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- How does  $X$  work?
- History of quantitative knowledge
- Modern techniques for understanding our world

# How does X work?

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## Examples:

- MRI machines
- Quantum dot televisions
- LIGO (gravity waves)
- Radio interferometers (VLA, ALMA, etc.)
- Historical device such as the Antikythera mechanism

# History of quantitative knowledge

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## Examples:

- Mapping of the Pacific Northwest (including techniques used)
- Birth of computing during the second world war (including how they worked)
- History of medical imaging (X-rays to MRI)
- Development of longitude techniques in the 18<sup>th</sup> century

# Modern techniques for understanding our world

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The most challenging to formulate, and will probably require some conversation with me

Examples:

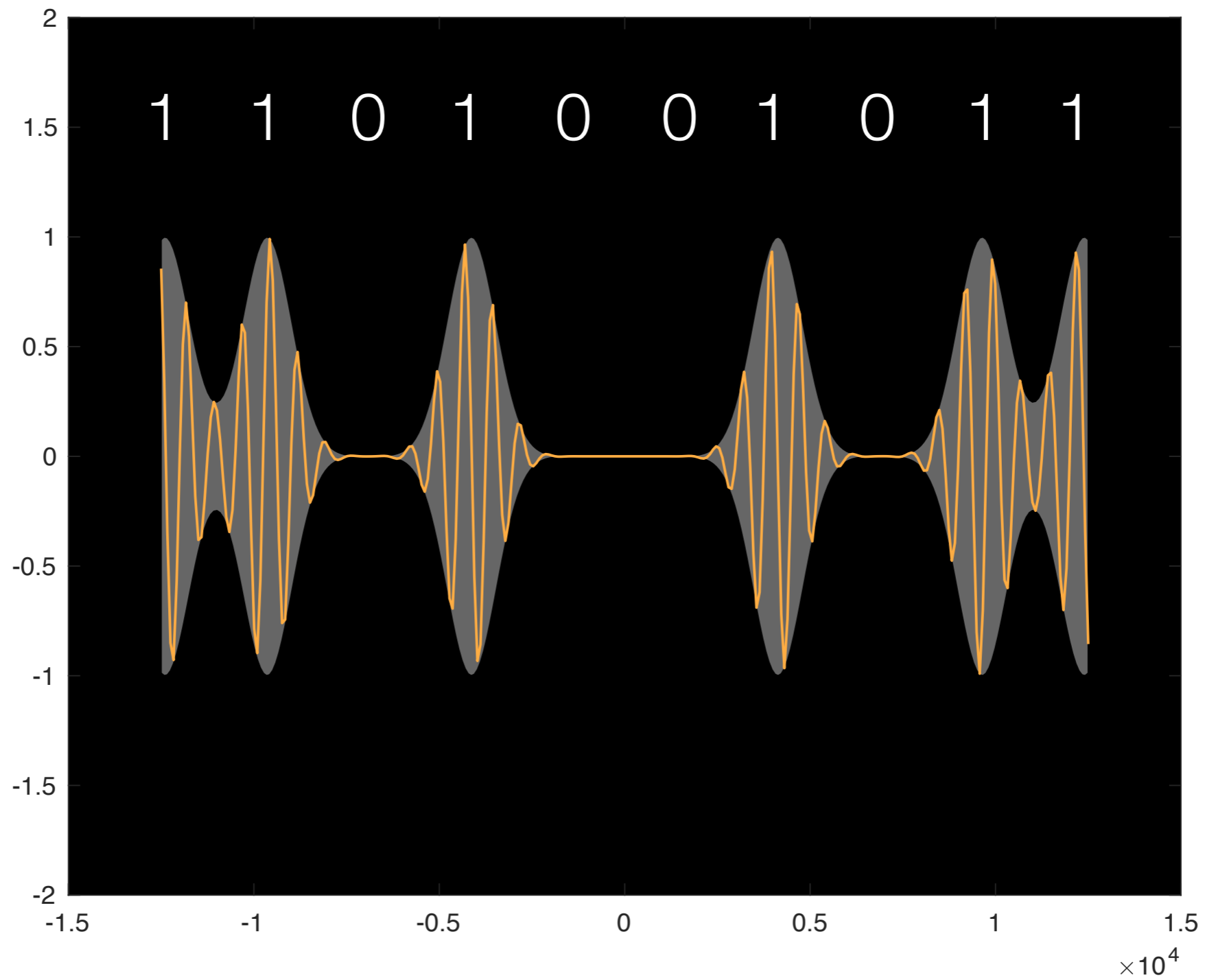
- Imaging the brain in action (fMRI, PET, and other tools)
- Tracking volcanos (GPS, satellite and arial LIDAR, etc.)
- Measuring gravity waves (LIGO, nanoGrav, LISA)

# Bandwidth

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# Sending information

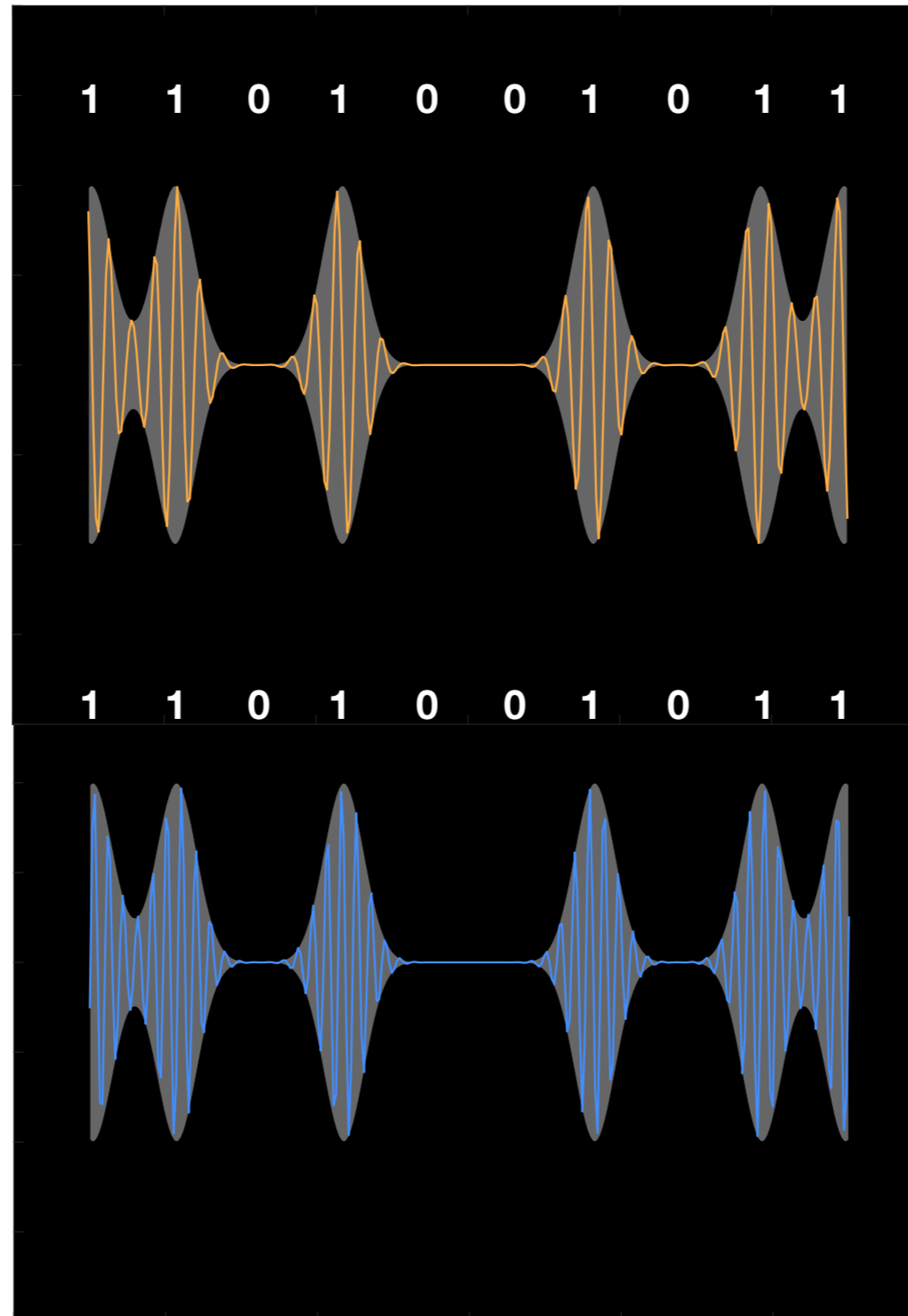
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# Sending information with different colors

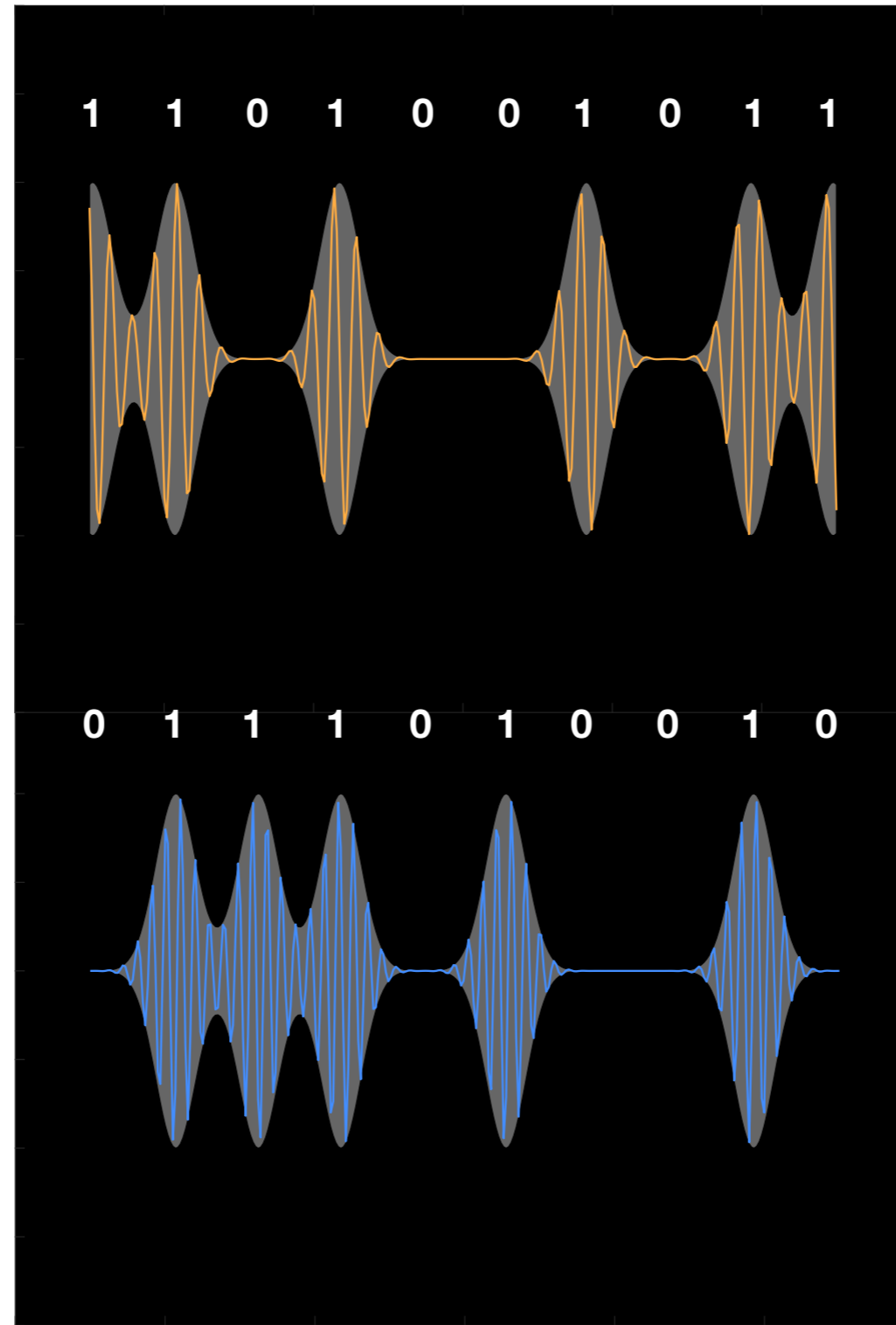
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# Giving each person their own color

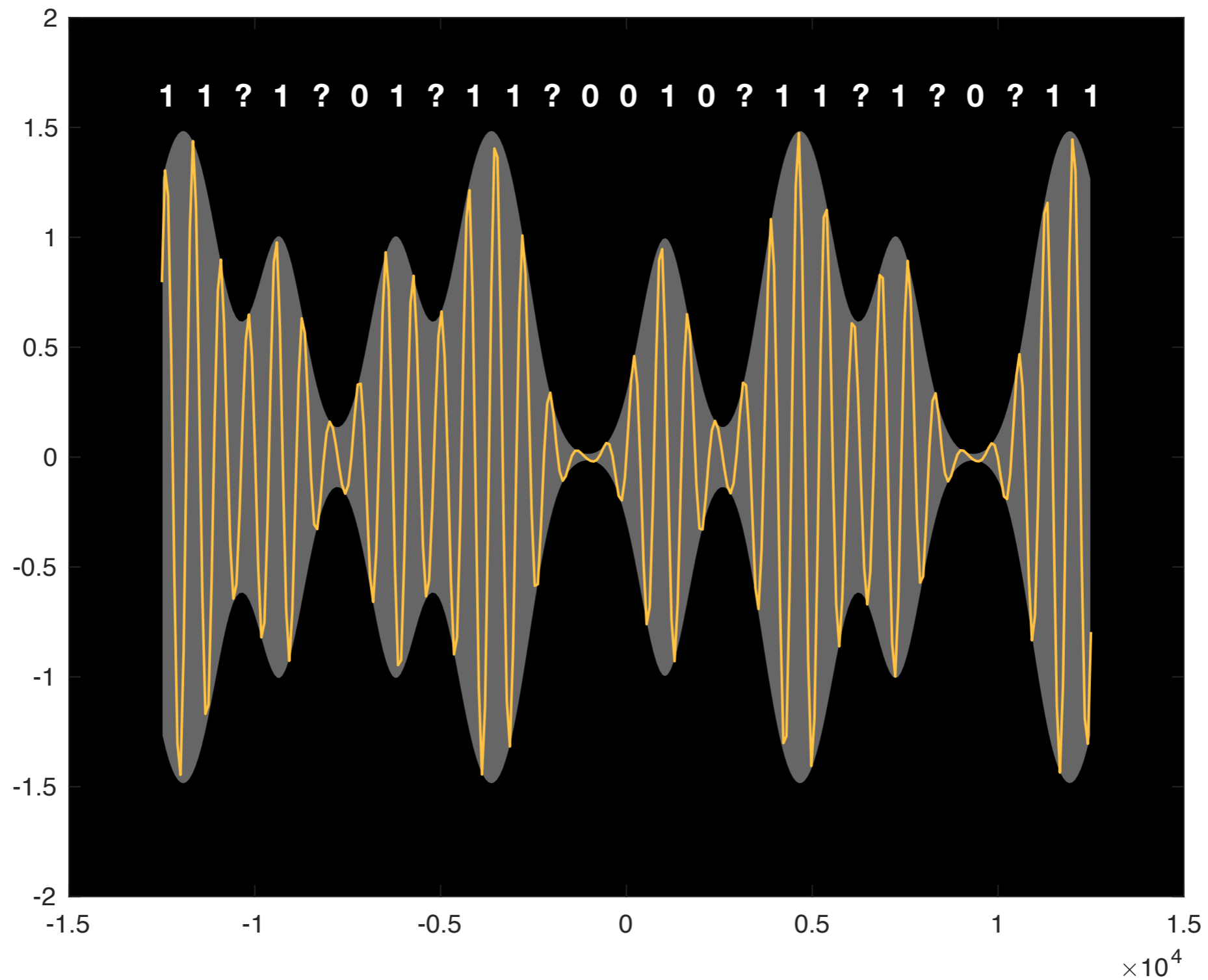
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Prism used  
to separate  
colors or  
'channels'



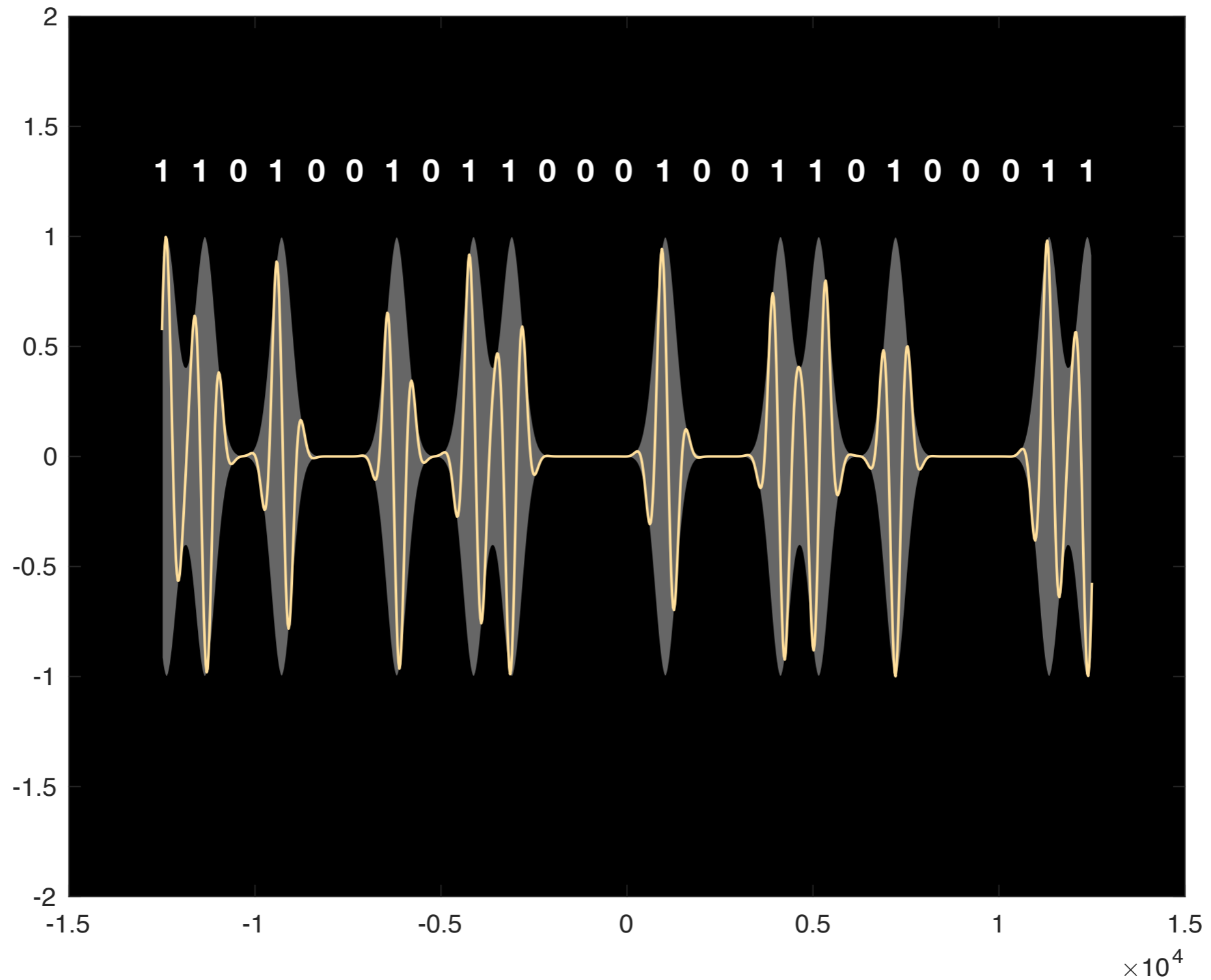
If I try to send pulses too fast, message is garbled

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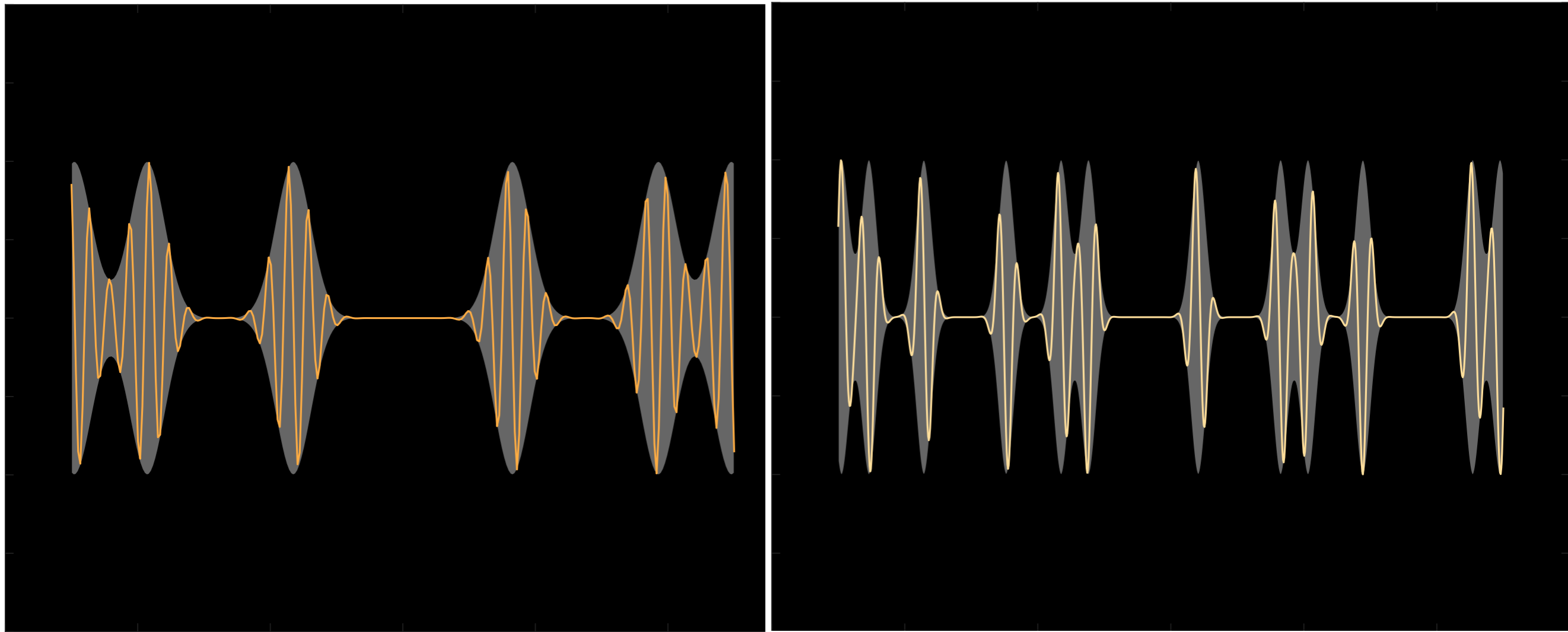
To send a message faster I need shorter pulses

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Speed depends on *range* of color (bandwidth)

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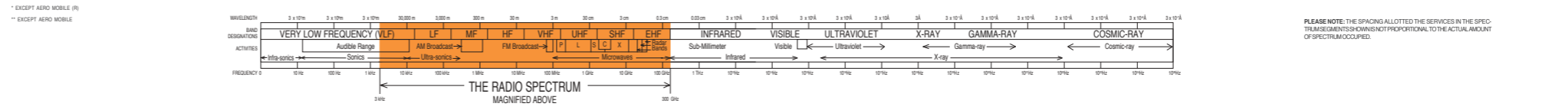


# Key ideas

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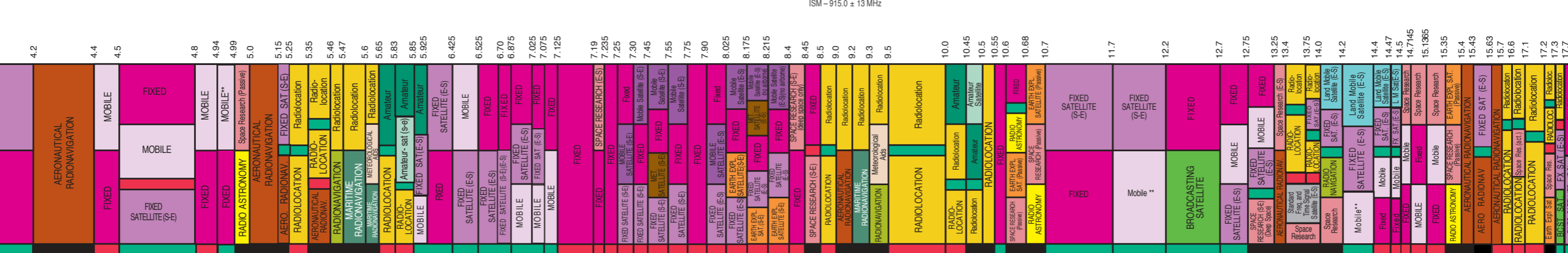
- More color (bandwidth), the ***faster*** the data can be sent
- Each user can get their own ‘color’ range
- Users don’t really care what color they have, but do care about how wide the color range is (bandwidth)
- Can have many slow users, or a few fast users, but color range is preserved
- You buy a color range (bandwidth)

# UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM

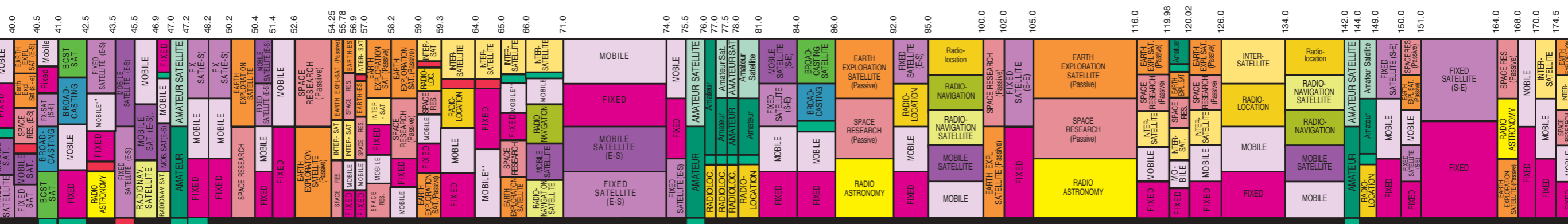


\* EXCEPT AERO MOBILE (R)  
 \*\* EXCEPT AERO MOBILE

PLEASE NOTE: THE SPACING ALLOTTED THE SERVICES IN THE SPECTRUM CHART IS NOT PROPORTIONAL TO THE ACTUAL AMOUNT OF SPECTRUM OCCUPIED.

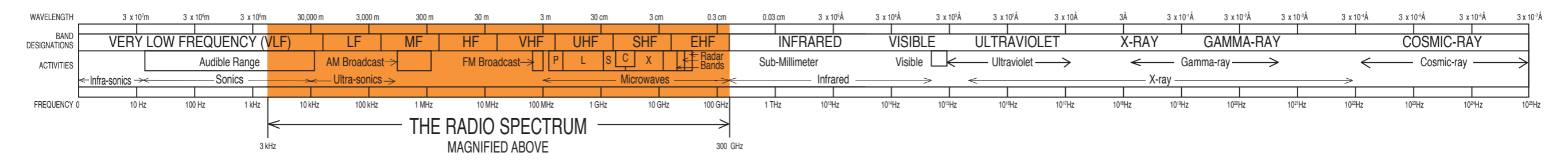


ISM - 5.8 ± .075 GHz



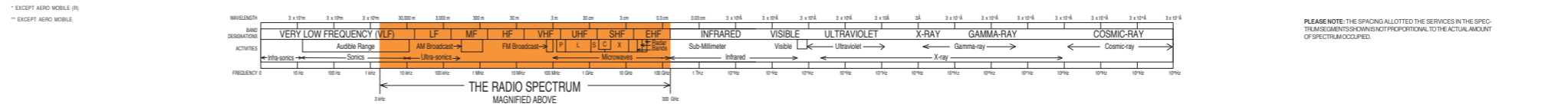
ISM - 61.25 ± .250 GHz  
59-64 GHz IS DESIGNATED FOR UNLICENSED DEVICES

ISM - 122.5 ± .500 GHz





# UNITED STATES FREQUENCY ALLOCATIONS THE RADIO SPECTRUM



Frequency (MHz)	Service / Band	Notes
7.30	Mobile Satellite (S-E)	
7.35	BROADCASTING (AM RADIO)	
7.45	Mobile Satellite (S-E)	
7.46	Mobile	
7.47	Mobile	
7.48	Mobile	
7.52	Mobile	
7.54	Mobile	
7.60	Mobile	
7.75	Mobile	
8.025	Mobile Satellite (E-S)	
8.175	Mobile Satellite (E-S)	
8.215	Mobile Satellite (E-S)	
8.4	Mobile Satellite (E-S)	
8.45	Mobile Satellite (E-S)	
8.5	Mobile Satellite (E-S)	
9.0	Mobile Satellite (E-S)	
9.2	Mobile Satellite (E-S)	
9.3	Mobile Satellite (E-S)	
9.5	Mobile Satellite (E-S)	
10.0	Mobile Satellite (E-S)	
10.45	Mobile Satellite (E-S)	
10.5	Mobile Satellite (E-S)	
10.55	Mobile Satellite (E-S)	
10.6	Mobile Satellite (E-S)	
10.68	Mobile Satellite (E-S)	
10.7	Mobile Satellite (E-S)	
11.7	Mobile Satellite (E-S)	
12.2	Mobile Satellite (E-S)	
12.7	Mobile Satellite (E-S)	
12.75	Mobile Satellite (E-S)	
13.25	Mobile Satellite (E-S)	
13.4	Mobile Satellite (E-S)	
13.75	Mobile Satellite (E-S)	
14.0	Mobile Satellite (E-S)	
14.2	Mobile Satellite (E-S)	
14.4	Mobile Satellite (E-S)	
14.47	Mobile Satellite (E-S)	
14.5	Mobile Satellite (E-S)	
14.7145	Mobile Satellite (E-S)	
15.1365	Mobile Satellite (E-S)	
15.35	Mobile Satellite (E-S)	
15.4	Mobile Satellite (E-S)	
15.43	Mobile Satellite (E-S)	
15.63	Mobile Satellite (E-S)	
15.7	Mobile Satellite (E-S)	
16.6	Mobile Satellite (E-S)	
17.1	Mobile Satellite (E-S)	
17.2	Mobile Satellite (E-S)	
17.3	Mobile Satellite (E-S)	
17.7	Mobile Satellite (E-S)	
17.8	Mobile Satellite (E-S)	
18.3	Mobile Satellite (E-S)	
18.6	Mobile Satellite (E-S)	
18.8	Mobile Satellite (E-S)	
19.3	Mobile Satellite (E-S)	
19.7	Mobile Satellite (E-S)	
20.1	Mobile Satellite (E-S)	
20.2	Mobile Satellite (E-S)	
21.2	Mobile Satellite (E-S)	
21.4	Mobile Satellite (E-S)	
22.0	Mobile Satellite (E-S)	
22.21	Mobile Satellite (E-S)	
22.5	Mobile Satellite (E-S)	
22.55	Mobile Satellite (E-S)	
23.55	Mobile Satellite (E-S)	
23.6	Mobile Satellite (E-S)	
24.0	Mobile Satellite (E-S)	
24.05	Mobile Satellite (E-S)	
24.25	Mobile Satellite (E-S)	
24.45	Mobile Satellite (E-S)	
24.65	Mobile Satellite (E-S)	
24.75	Mobile Satellite (E-S)	
25.05	Mobile Satellite (E-S)	
25.25	Mobile Satellite (E-S)	
25.5	Mobile Satellite (E-S)	
27.0	Mobile Satellite (E-S)	
27.5	Mobile Satellite (E-S)	
29.5	Mobile Satellite (E-S)	
29.9	Mobile Satellite (E-S)	
30.0	Mobile Satellite (E-S)	
73.0	Mobile	
74.6	Mobile	
74.8	Mobile	
75.2	Mobile	
75.4	Mobile	
76.0	Mobile	
88.0	Mobile	
108.0	Mobile	
117.975	Mobile	
121.9375	Mobile	
123.0875	Mobile	
123.5875	Mobile	
128.8125	Mobile	
132.0125	Mobile	
136.0	Mobile	
137.0	Mobile	
137.025	Mobile	
137.175	Mobile	
137.825	Mobile	
138.0	Mobile	
144.0	Mobile	
146.0	Mobile	
148.0	Mobile	
149.9	Mobile	
150.05	Mobile	
150.8	Mobile	
152.855	Mobile	
154.0	Mobile	
156.2475	Mobile	
157.0375	Mobile	
157.1875	Mobile	
157.45	Mobile	
161.575	Mobile	
161.625	Mobile	
161.775	Mobile	
162.0125	Mobile	
173.2	Mobile	
173.4	Mobile	
174.0	Mobile	
174.4	Mobile	
174.8	Mobile	
175.5	Mobile	
177.9	Mobile	
179.7	Mobile	
18.03	Mobile	
18.068	Mobile	
18.168	Mobile	
18.78	Mobile	
18.9	Mobile	
19.02	Mobile	
19.68	Mobile	
19.80	Mobile	
19.990	Mobile	
19.995	Mobile	
20.005	Mobile	
20.010	Mobile	
21.0	Mobile	
21.45	Mobile	
21.85	Mobile	
21.924	Mobile	
22.0	Mobile	
22.855	Mobile	
23.0	Mobile	
23.2	Mobile	
23.35	Mobile	
24.89	Mobile	
24.99	Mobile	
25.005	Mobile	
25.07	Mobile	
25.21	Mobile	
25.33	Mobile	
25.55	Mobile	
25.67	Mobile	
26.1	Mobile	
26.175	Mobile	
26.48	Mobile	
26.95	Mobile	
26.96	Mobile	
27.23	Mobile	
27.41	Mobile	
27.54	Mobile	
28.0	Mobile	
29.7	Mobile	
29.8	Mobile	
29.89	Mobile	
29.91	Mobile	
30.0	Mobile	

# Spectrum Analyzer

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