WWV/H Scientific Modulation Working Group

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TAPR DCC, 17-18 September 2021

Objective

Develop recommendations for additions to WWV/WWVH modulation that can be used for scientific purpose, particularly through the Personal Space Weather Station and citizen science campaigns.

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Working Group Members

- NIST Leadership
- WWV/WWVH Staff
- Geospace scientists
- Engineers
- WWV Amateur Radio Club, WW0WWV

- A current list is found at https://zenodo.org/record/5182323
- Membership evolves as tasks evolve: will move back and forth between science and engineering

Work to Date

- 16 February 2021: AD8Y invites K0WWX to HamSCI meeting. NIST requests talk from HamSCI on scientific use of WWV/H; idea of additional modulation proposed
- 25 March 2021: W1PJE and WA5FRF deliver seminar to NIST Time and Frequency Division on WWV measurements
- 10 May 2021: First working group meeting convened; design principles discussed by W1PJE; stations' license privileges established
- 6 June 2021: Station engineers suggest adding test chirp
- 28 June 2021: Second meeting; plans for characterization signal discussed
- June → August: Characterization signal developed via email
- 10 August 2021: Third meeting; characterization signal finalized

Design Principles

- *Primum non nocere*: First, do no harm. Avoid disturbing existing WWV use cases, including listening comfort, at all costs.
- Goal: do something useful for science AND for WWV's prime customers of time and frequency. (WWV is an operational service of NIST Time and Frequency division.)
  - Where possible, identify opportunities to increase utility for existing users outside of geospace
- What science question can we focus on by doing something more than we already have today?
  - Consider a multi-method approach to frontier questions: how can WWV augment existing instrumentation networks?

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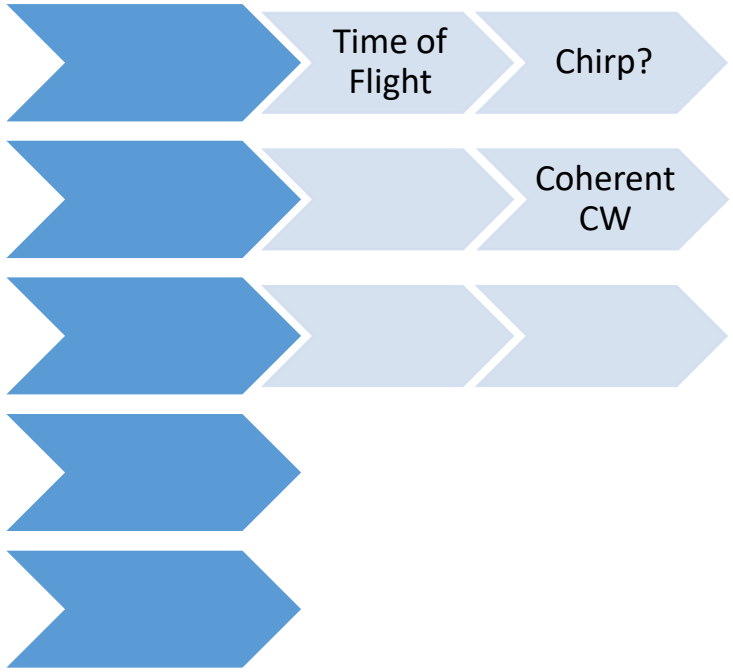
Design Space

- We've discussed Time of Flight, which is an example of an observation variable.
- Coherent CW, pseudorandom codes, etc. – nifty but not yet connected to a science objective
- This is only one part of the problem space.
- **We will consult with experts outside the working group to populate a science traceability matrix.**



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Characterization Signal

- 45 second WAV file on minute 8 for WWV, 48 for WWVH
  - Submitted as a standard voice announcement
- First step: Characterize signal chain from WAV file to signal leaving the antenna.
- Receiving stations: KiwiSDR recording, possible crowdsourced campaign
- Opportunity to prototype receiving stations and processing
- Results will inform further discussion and development

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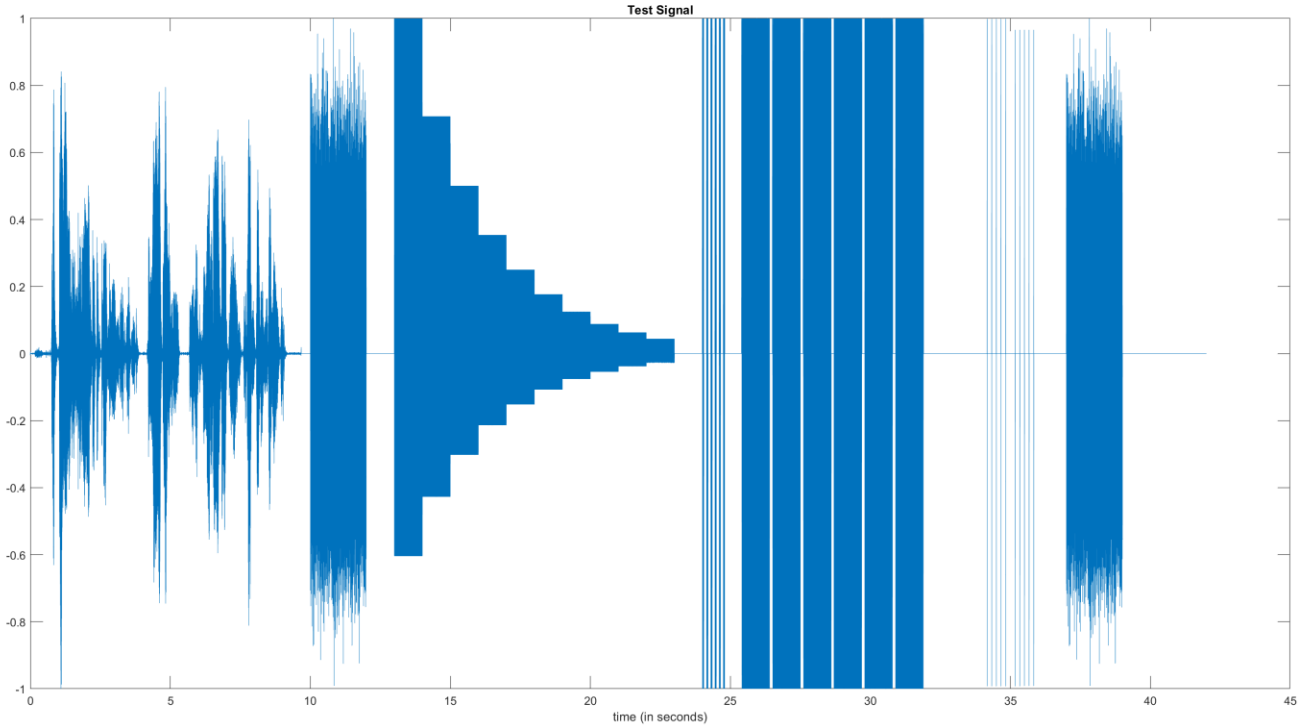
Characterization Signal



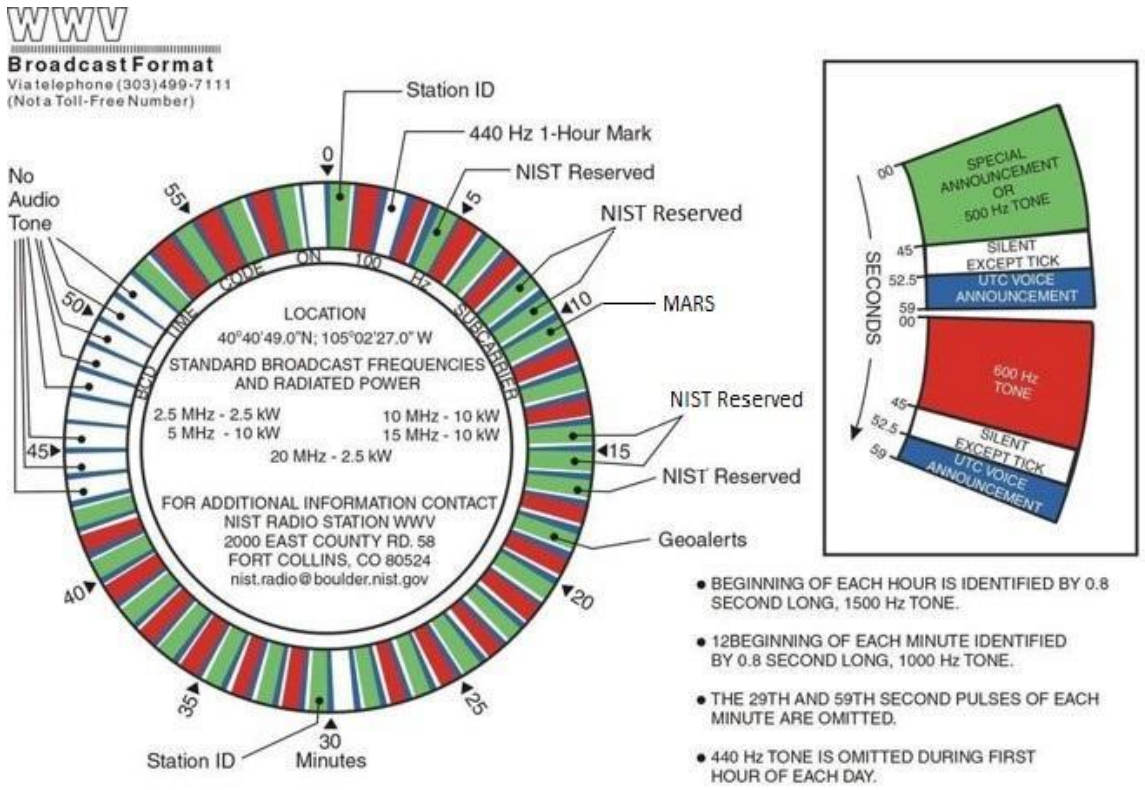
•10 second voice announcement.
•Gaussian white noise (2 seconds).
•One second blank time.
•Phase-coherent 2, 3, 4, 5 kHz sine waves that drop down by 3 dB 9 times, 10 seconds total.
•One second blank time.
•An eight-second sequence consisting of linear up-chirps and down-chirps, generated with MATLAB: long is 5 kHz over 1 second (TBW = 5,000), short is 5 kHz over 0.05 seconds (TBW = 250).
To wit: 3 short up, 3 short down, .5 seconds blank, 3 long up, 3 long down. 100 ms between chirps and at the end of each sub-sequence.
•2 seconds blank time.
•A one-cycle burst at 2.5 kHz frequency, for time domain measurement, repeated 5 times over the course of 1 second; then the same for 5 kHz.
•One second blank time.
•Repeated 2 seconds of Gaussian white noise for synchronization. Same sequence.
•3 seconds blank time.

Next Steps

- Listen for the signal on WWV and WWVH – *coming soon!*
  - WWV: Minute 8
  - WWVH: Minute 48
- Characterization signal:

DOI 10.5281/zenodo.5182323

- More information: www.hamsci.org/wwv



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