Software Defined Radio without the Radio

Using GNU Radio and a sound card to develop a receiver for atomic time from WWVB

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Topics

- WWVB and a little about its history
- Reasons I am interested in WWVB
- Receiving WWVB with a soundcard
- GNUradio example demodulation

Just to level with you …

- Interactive is good
  - Please do not hold your questions, interrupt!
  - Please do not hold your corrections, this is new material for me
- What this talk will not include:
  - Live reception, or event recent reception of WWVB
  - Large antennas
  - Fully functional demodulator

This is very much a work in progress

What is WWVB?

- NIST-run time broadcasts on 60kHz
- 70kW radiated power from Fort Collins, CO
  - receivable across lower 48 states
- Time source for your “atomic” wall clocks
  - NIST prefers: Radio Controlled Clocks
  - These clocks typically sync only at night
- Time service predates GPS
  - On the air since July 5, 1963

Why am I interested in WWVB?

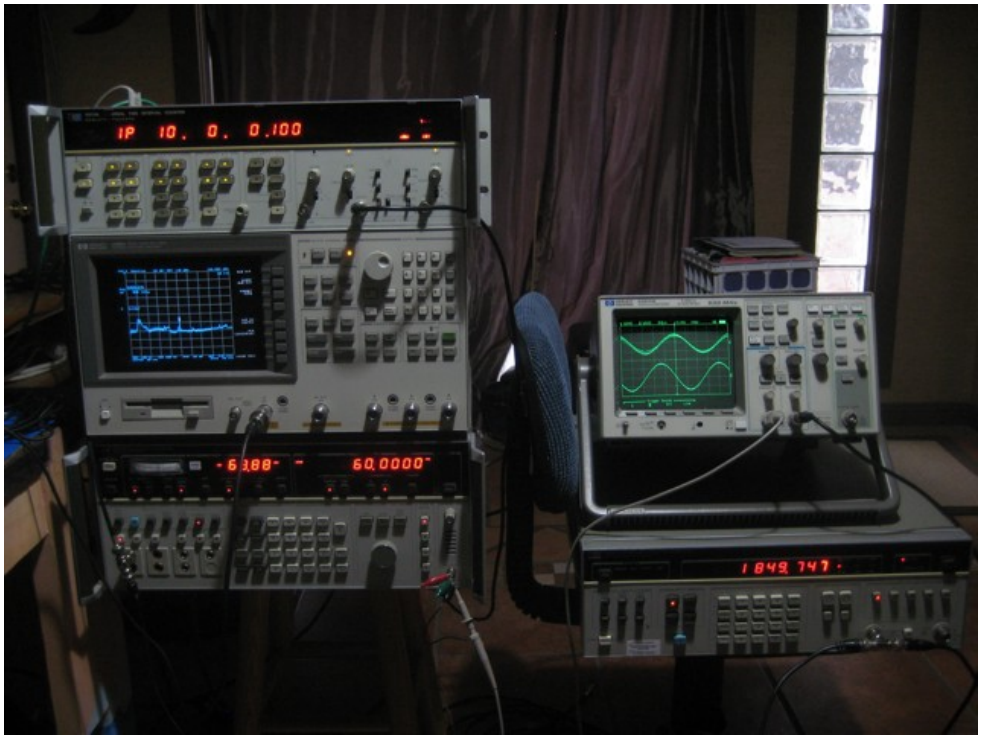
- A path to learn and dabble in digital comms
  - PWM time code
  - BPSK time code since 2013
- Learn more about antennas and propagation
  - Ground waves
  - Atmospheric disturbances
- Accurate Frequency Reference
  - NIST claims frequency uncertainty less than 1e-12

Receiving WWVB with a soundcard

- Direct Sampling
  - 192kHz sound cards are available
    - mine were only 48kHz on the line in/mic
- Resonant Loop Antennas
  - http://www.ka7oei.com/wwvb_antenna.html
  - http://www.c-max-time.com/

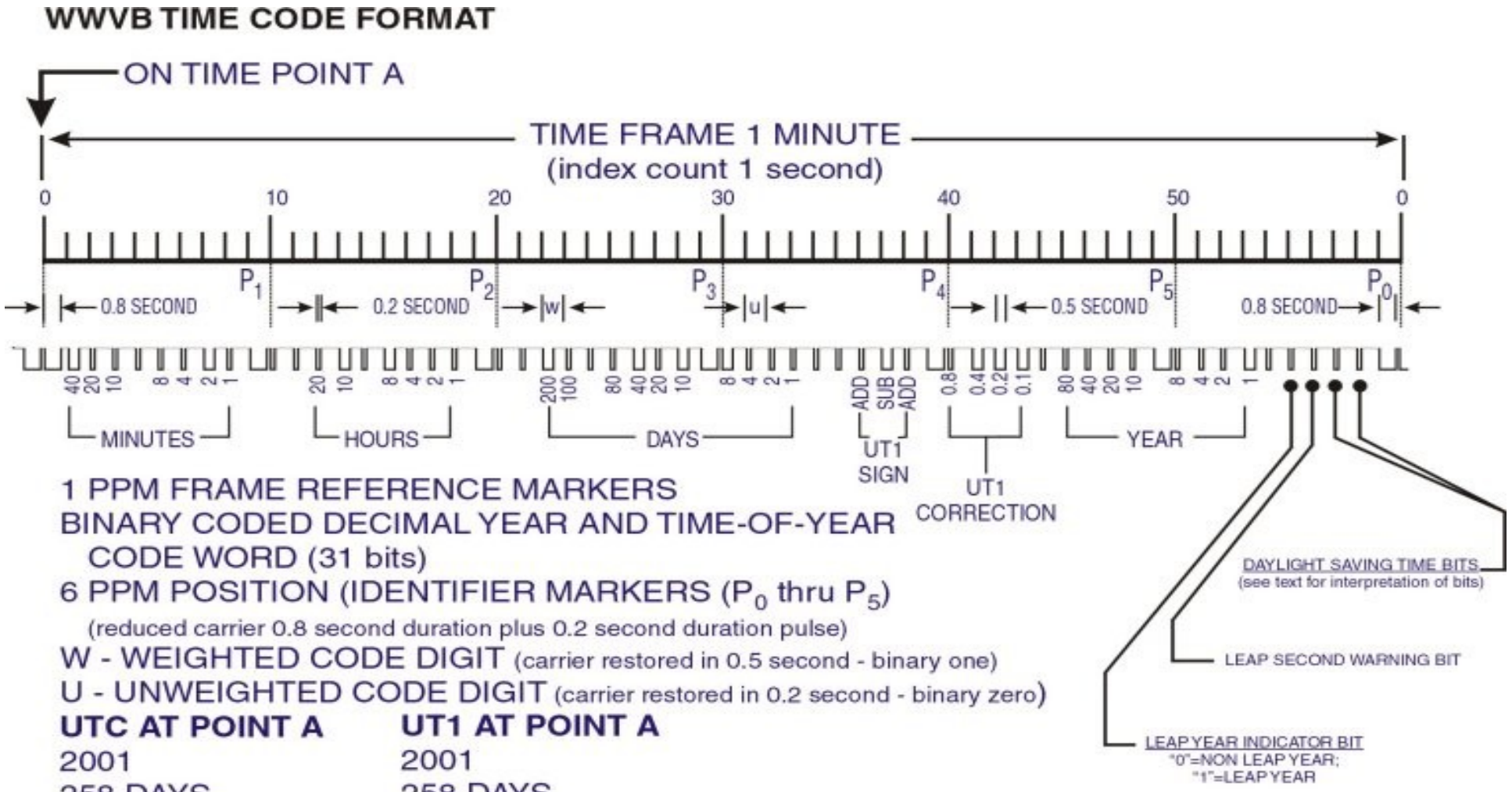
Receiving WWVB with a soundcard

- Proof of concept
  - http://www.jks.com/wwvb/wwvb.html



- Fortunately, they provide a nice recording:
  - http://www.jks.com/wwvb/ant.wide.5min.15.625.kHz.44.1k.24b.au

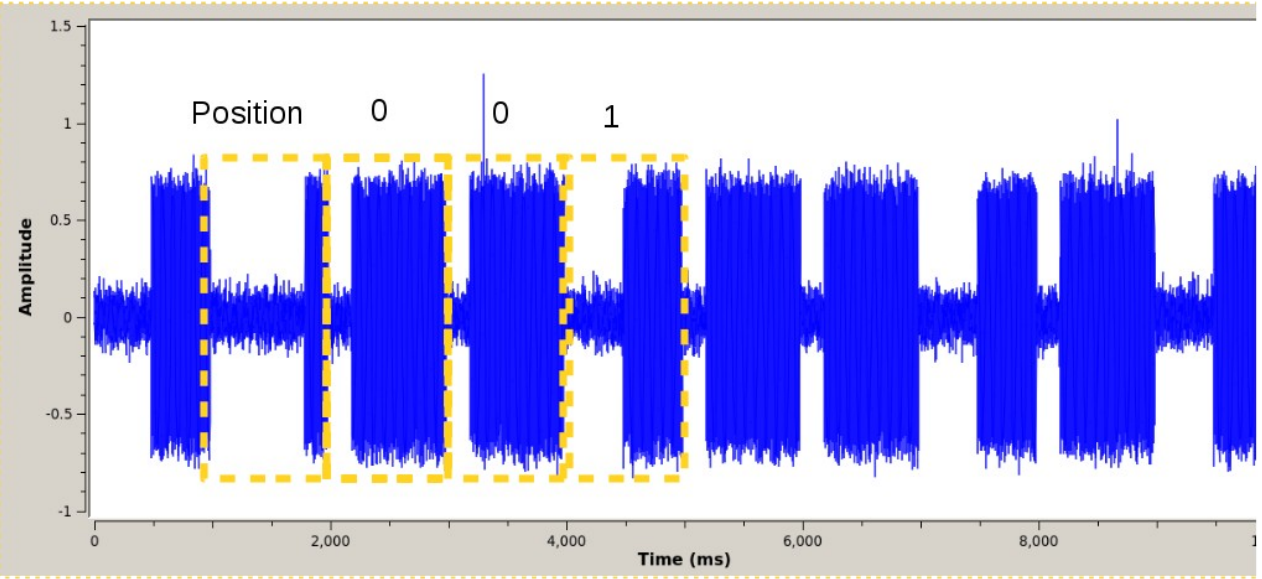
Demodulating WWVB



1 PPM FRAME REFERENCE MARKERS
BINARY CODED DECIMAL YEAR AND TIME-OF-YEAR
CODE WORD (31 bits)
6 PPM POSITION (IDENTIFIER MARKERS (P_0 thru P_5)
(reduced carrier 0.8 second duration plus 0.2 second duration pulse)
W - WEIGHTED CODE DIGIT (carrier restored in 0.5 second - binary one)
U - UNWEIGHTED CODE DIGIT (carrier restored in 0.2 second - binary zero)

UTC AT POINT A	**UT1 AT POINT A**
2001	2001
258 DAYS	258 DAYS
18 HOURS	18 HOURS
42 MINUTES	41 MINUTES
	59.3 SECONDS

Demodulating WWVB



- Modulation Format
  - 1 bit per second AM-PWM
    - Drops amplitude by 17dB at start of bit
    - “1” restores amplitude at 0.5 seconds
    - “0” restores amplitude at 0.2 seconds
    - “Position Start” restores amplitude at 0.8 seconds
      - Used to mark separation of Hours, Minutes, etc
    - “Frame Start/End” uses two consecutive Position Start bits
      - Used to mark the beginning of the next 1 minute frame

Demodulating WWVB

- Frame Format
  - 60 bits (1 minute to transmit)
    - Minutes: 10 bits
    - Hours: 10 bits
    - Days + UT1 Sign: 20 bits
    - UT1 Correction + Year + DST + Leap Second: 20 bits