The Grape III Beacon Receiver: Pondering New Varietals for the RF Vineyard

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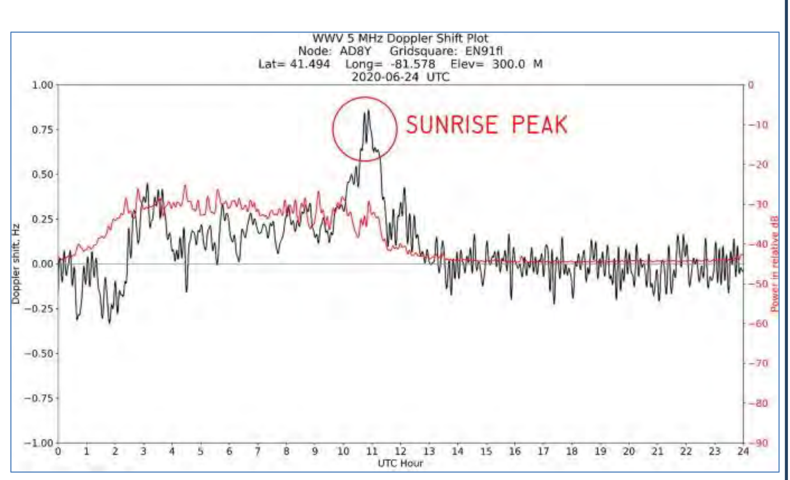
Abstract

HamSCI's ionosphere-sounding beacon receivers have evolved. Grape I is a straightforward low-IF receiver based on the venerable NE612 Gilbert cell chip. Grape II is a much more involved 3-frequency, computer-controlled receiver. What might the Grape III will be? The CWRU Grape team will discuss possibilities for the next generation of inexpensive, high-accuracy receivers that will provide HamSCI, NIST, Canadian Research Council, and others a continuous data stream. Anticipation of signal processing, ease of manufacture, and ease of deployment will be among the top issues. Several receiver architectures and data collection modalities will be considered along with candidate signal analysis approaches and related chipsets. Notes will be taken from audience questions and suggestions, and new design teams will be solicited for the project.

Introduction

The HamSCI beacon-receiving work at CWRU began with a class lab project. The AA0ZZ 40 meter direct-conversion receiver (*QST* for July 2016) formed the basis of the project; it used the venerable NE602/612 Gilbert cell mixer chip and simple support circuits. Adding a GPS-disciplined oscillator and an analog-to-digital converter, we began recording WWV's carrier signals. Shown is an early sample of our daily WWV Doppler shift and signal-strength graphs.

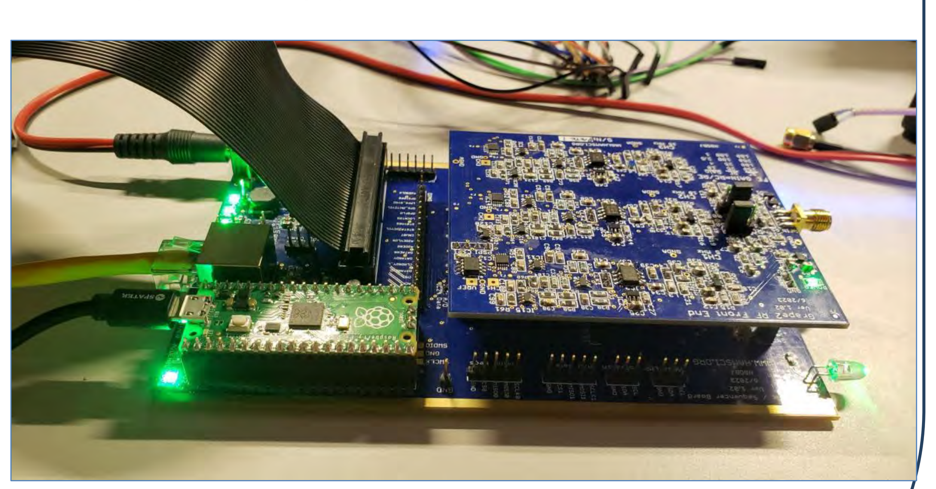
With many modifications, this evolved into the Grape I receiver. Note inputs for the GPS local oscillator and antenna, and output for the carrier mixed down to 1 kHz nominal.



Grape I board and a resulting WWV carrier graph

Grape II is also an NE612 low-IF receiver, but adds 3-frequency simultaneous reception, onboard frequency standards and A/D converters, improved filtering, microcontroller switching, and the most subtly toned LEDs N8OBJ could find.

It will provide signal reception, processing, and uploading for the next eclipse and the next era of HamSCI's ionospheric monitoring.



Grape II RF and computer boards, complete with LEDs

What's Next?

The modified AA0ZZ receiver and the following Grape I and Grape II have been in development, production, and use for seven years. Our expectation is that they will reliably provide ionospheric data for at least several more years but planning needs to begin now for the next version. The units' Gilbert cell integrated circuit is out of production, and new approaches will be needed for that reason alone. Consider some of the overlapping science and engineering uses:

Science: We want to know more about the ionosphere and its responses to space weather. Signal processing accuracy and ability to distinguish the various beacons' signals one from another will be of greatest importance.

Engineering: We want to explore new receiving techniques and signal processing methods for individual experimenters. the various radio beacons' signals. Low cost, flexible designs and visual data presentation may be more important than laboratory accuracy.

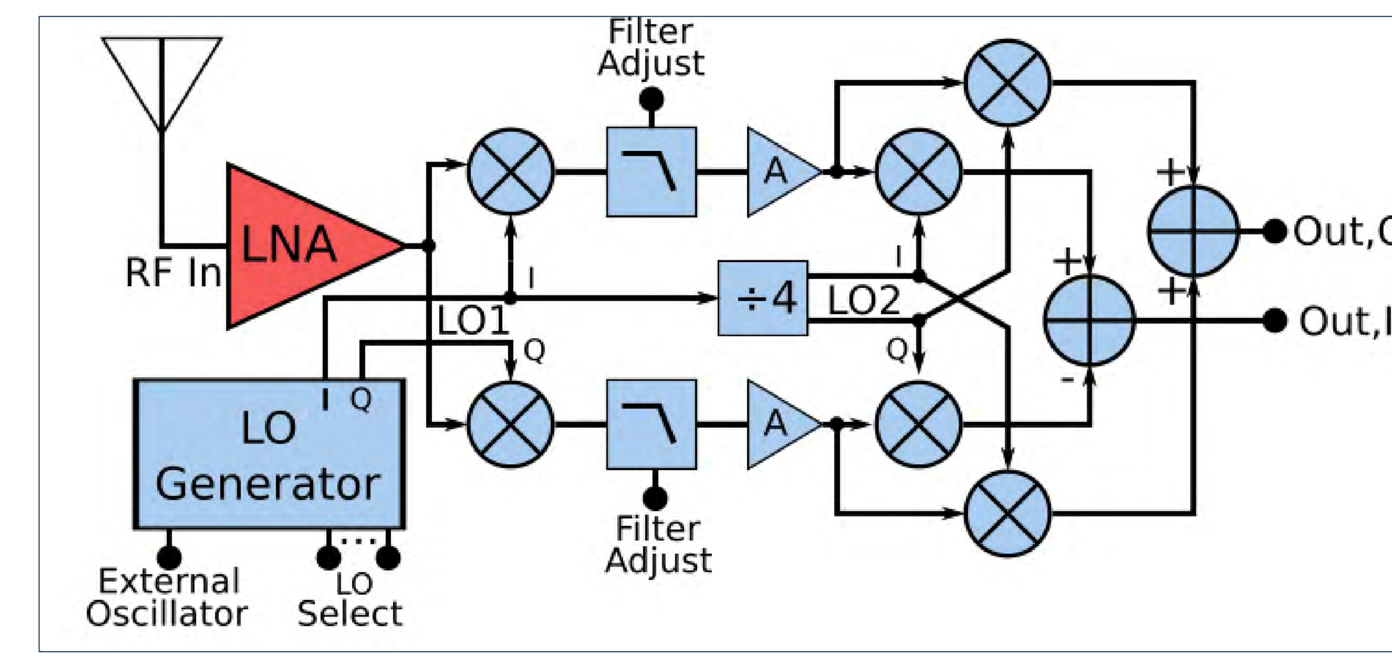
Public service: We want to provide the beacon managers such as NIST and NRC methods to monitor distribution of their signals. We also want web pages that show to the amateur and SWL communities real-time propagation information.

The farther-flung: We want to support speculative projects such as the use of time-clock stations as imaging and navigation signals. Can KE8HHV navigate by the heartbeat of the electromagnetic spectrum alone?

Kellen and her WWV receiver on Inisharon.
She likely has a sextant, also.

Approaches to consider. Maybe this is *your* task!

The Grape I and II are low-IF receivers meant to record carrier Doppler shift. They depend on external frequency sources for their accuracy. Continuing that architecture with a new mixer structure might include a **Weaver image-rejection I-Q** system, which by coincidence of WWV/H's frequencies is a nice match to the problem:



An image-rejecting double-mixer Weaver receiver

The CWRU CHU Along-Path eclipse study group took a different approach. They used a receiver with an **AM detector** and examine the signals' modulation structure. Many inexpensive receivers use Silicon Labs Si4825/27/36 AM/FM/SW receiver chips, which are quite suitable for time-of-flight measurements using WWV/H and CHU second ticks. AGC is software controllable, so signal amplitude may be measured. GPS pulse-per-second is much less expensive and more compact to obtain than disciplined IF signals are. **Signal differentiation** such as for WWV/H is possible with second tick or tone modulation frequency analysis. For example, see those two stations' tick structures on 1000 and 1200 Hz: https://www.nist.gov/pml/time-and-frequency-division/time-distribution/radio-station-wwv/wwv-and-wwvh-digital-time-code

Welcome to the poster! Let's talk about it!

References

Mac Russell, David Kazdan, and Soumyajit Mandal, "A Monolithic CMOS Realization of the Double-Quadrature Image-Reject Weaver Receiver," 2020 IEEE International Symposium on Circuits and Systems (ISCAS), Seville, Spain, 2020, pp. 1-5, doi: 10.1109/ISCAS45731.2020.9180569.

Silicon Labs Si4825 datasheet: https://www.skyworksinc.com/-/media/Skyworks/SL/documents/public/data-sheets/Si4825-A10.pdf

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