USING GPS TO ENHANCE AMATEUR COMMUNICATIONS

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So - What is GPS

- Global Positioning Satellite system
- Array of multiple satellites for navigation and location.
  - Measures the precise time taken for the signal to reach you from several satellites
  - So, they have to know the exact time and be locked together.
  - And, they have to be able to transfer this data to you.

GPS Timing

- Each satellite carries a Caesium clock, which is corrected regularly by the operators. So GPS knows the time to within a few nano-seconds of UTC
- This is transmitted to the ground as data and a spread spectrum code so we now know ...
- **THE EXACT TIME to within a few tens of ns - anywhere in the world**
- (and we also know where we are)

Stable & Accurate Frequency

- Time is   1 / Frequency
- Having this sort of accuracy for time distribution, we can correct and calibrate oscillators.
- Use directly for frequency sources if we can lock to the timing signal.

How do we use this service ?

- A handheld GPS receiver is no use
  - We need access to the timing info.
- Enter the GPS module.
  - Receiver and decoder subsystem on a small PCB
  - Generates the raw navigation data and provides a 1 Pulse-Per-Second signal (PPS), synchronised to UTC
  - Usually controlled via a serial (RS232) link

GPS modules

Jupiter (Navman/Rockwell)

Garmin

Motorola Oncore

Trimble

(Others)

5V power supply, latest ones 3V or 3.3V, current < 100mA

Logic level outputs for PPS and data

Antenna power internally supplied

NMEA data

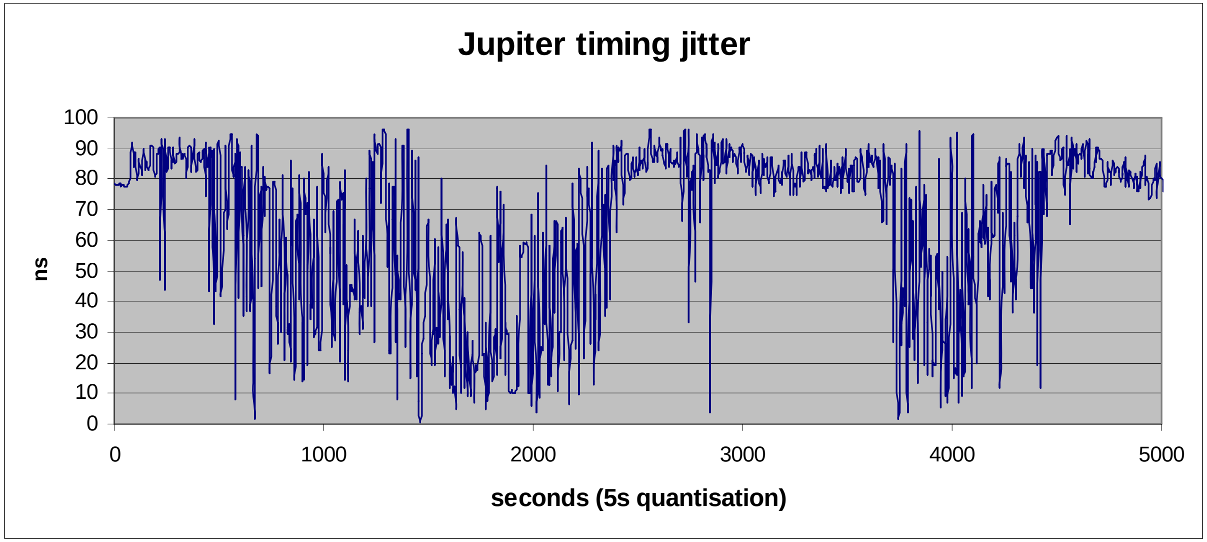
- **$GPRMC,212132,A,5054.5876,N,00117.4041,W,000.0,000.0,141202,003.5,W*7B**
- $GPGSA,A,3,,11,14,,28,31,,,,,,,3.7,2.4,2.7*38
- $GPGSV,2,1,06,03,23,146,,11,64,276,40,14,33,083,44,20,21,215,36*74

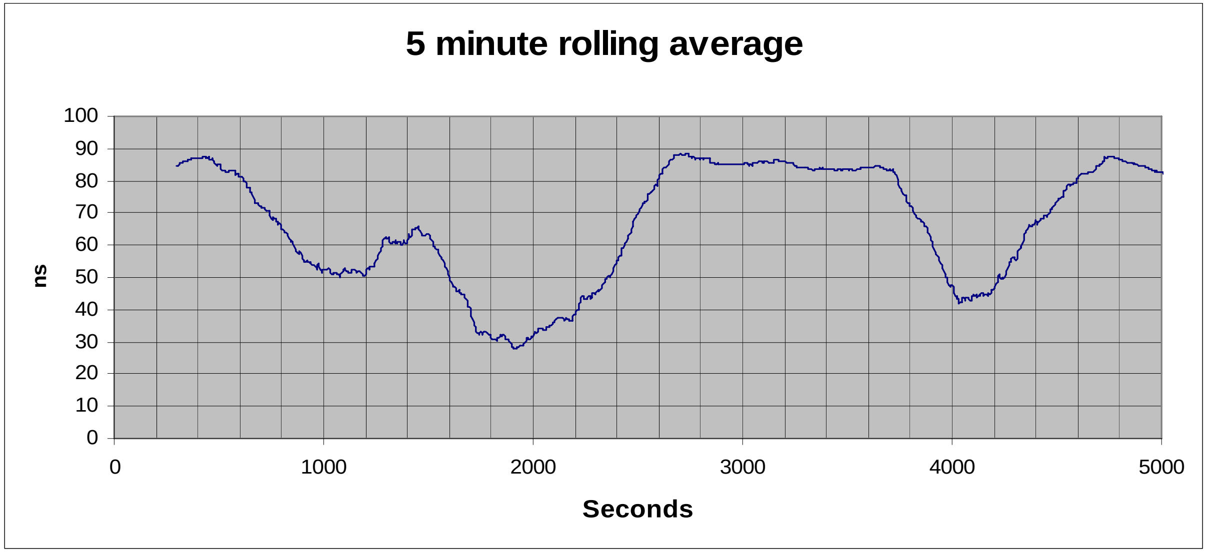
- Time Latitude Longitude Date
- HHMMSS DDmm.mmmm DDDmm.mmmm DDMMYY
- 21:21:32 UTC 50° 54.5876'N 1 ° 17.4041'W 14 December 2002

- **Repeated every second, AFTER the 1 PPS it refers to**
- **NMEA is not always the best, but can be simplest**
- **Standard on most modules, except when it isn't.**
- NOTE , some modules deliver decimal seconds, so beware when decoding :
- **$GPRMC,212132.0000,A,5054.5876,N,00117.4041....................**

- **So, use native binary data format if possible.**

PPS Timing Stability





The GPS Disciplined Oscillator

- The 1 PPS signal jitters considerably.
- Use to control a crystal oscillator within a Phase Locked Loop to smooth out wobbles
  - We have an “exact” 1Hz reference frequency now, but with ~200ns of jitter pulse to pulse.
  - Very long PLL time constant - tens of minutes to hours, so has to be digital with u-controller
  - Needs a very good oscillator to start with

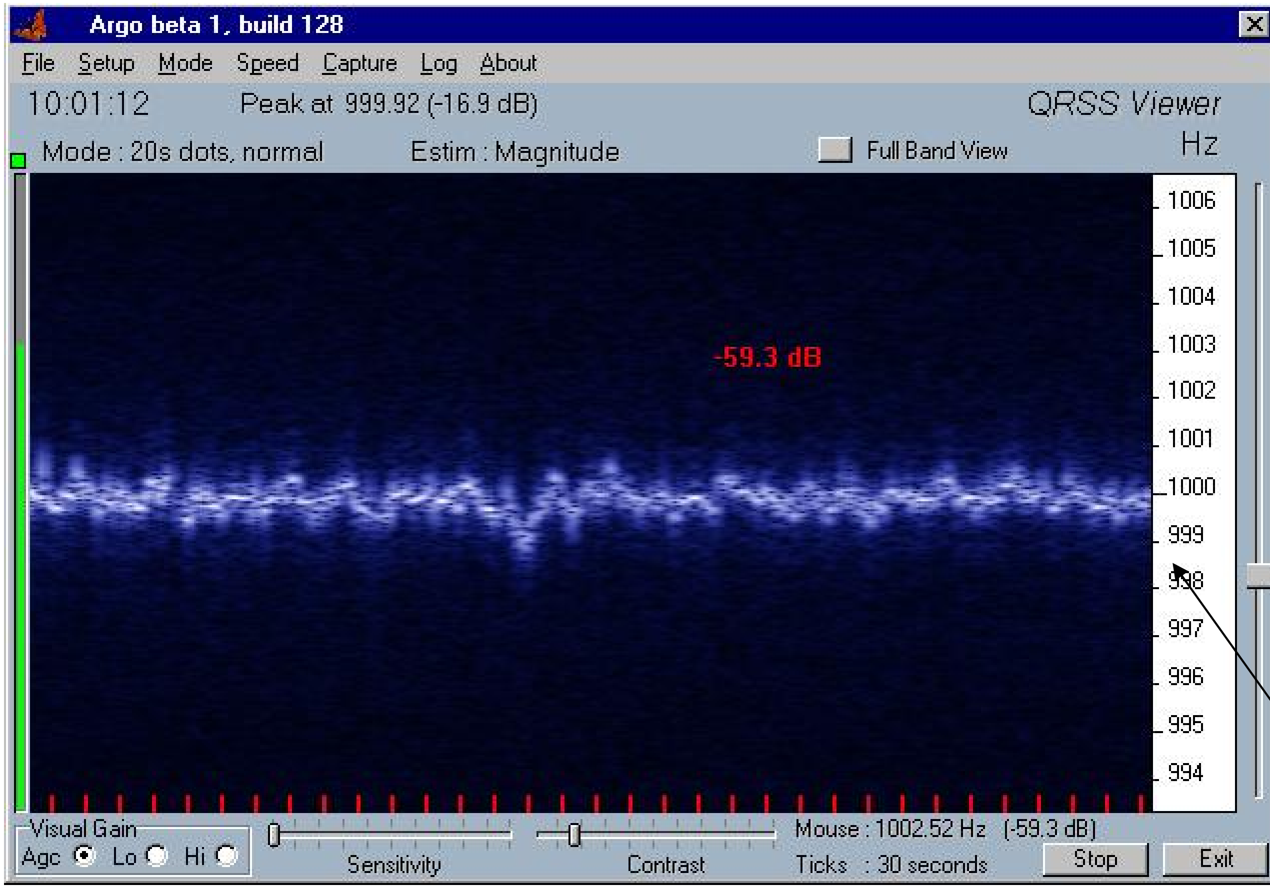
Typical full spec GPSDO

- Good quality ovenned crystal oscillator to generate a master reference (5 or 10MHz)
- Digital PLL, with time constant of several hours to smooth GPS jitters
  - CAN achieve a few parts in 10^{-11} short term frequency accuracy (sub Hz at 10GHz)
  - eg. The Brookes Sheera design
  - There is a much simpler solution, provided we accept a slightly reduced performance ....

The Simple GPSDO

- The Jupiter-T GPS module is (almost) unique in having a 10kHz output.
- Use this to phase lock a medium quality crystal oscillator (eg a TCXO)
  - A few HCMOS ICs and handful of R’s and C’s
  - Faster PLL time constant, quicker ‘warm up’
  - Less smoothing of GPS and Rx induced variations, usually gives a few parts in 10^{-9}
  - Hz to tens of Hz at microwaves

Simple GPSDO output stability



Multiplied to 1 GHz so 1Hz vertical == 10^{-9} ...

Timing

- Now we have accurate frequency, what can we use accurate time information for ?
  - We know that anyone with a GPS module, knows the EXACT TIME to within a few tens of ns, ANYWHERE IN THE WORLD.
  - This opens up huge opportunities for new signalling and experimental ideas !

Digital Modes

- All datamodes have to obtain, and keep, synchronisation between Tx and Rx
  - This is by far the biggest problem, and always the first to suffer when the signal gets weak and noisy.
  - All datamode decoding software spends (wastes) time and effort maintaining sync.
  - Often uses non-linear processing.

- PSK also has to acquire and maintain carrier coherence as well as timing-
  - Unless differential coding is used, in which case it is part compromised anyway as bits are dependent!
- What if we could do away with the need for lockup and acquisition altogether ?
  - Just concentrate on getting the signals out of the noise?
- Solution - Use GPS timing at each end.

Adding GPS timing to datamodes

- Most amateur datamode software uses the soundcard now.
  - So how do we get the timing into the PC?
  - We have to avoid extra hardware for widespread acceptance.
- Use the other audio channel
  - The RH channel lies idle in most setups
  - Used by G0TJZ for chirp-sounder monitoring software

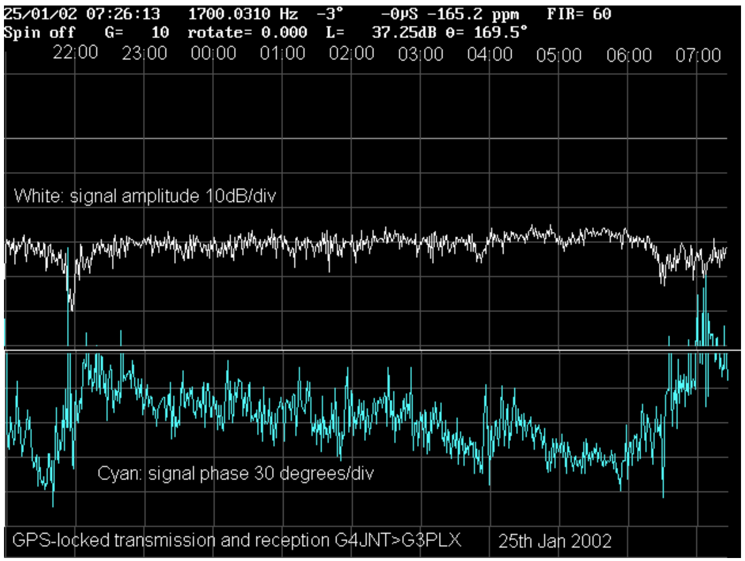
What is already out there ?

- Very little !
- Bill de Carle, VE2IQ has added GPS timing to his ‘Coherent’ or ‘Africa’ BPSK system.
  - Rather specialised and not in widespread use - not a simple system
- BUT shows promise.
  - Mainly in timing so far.

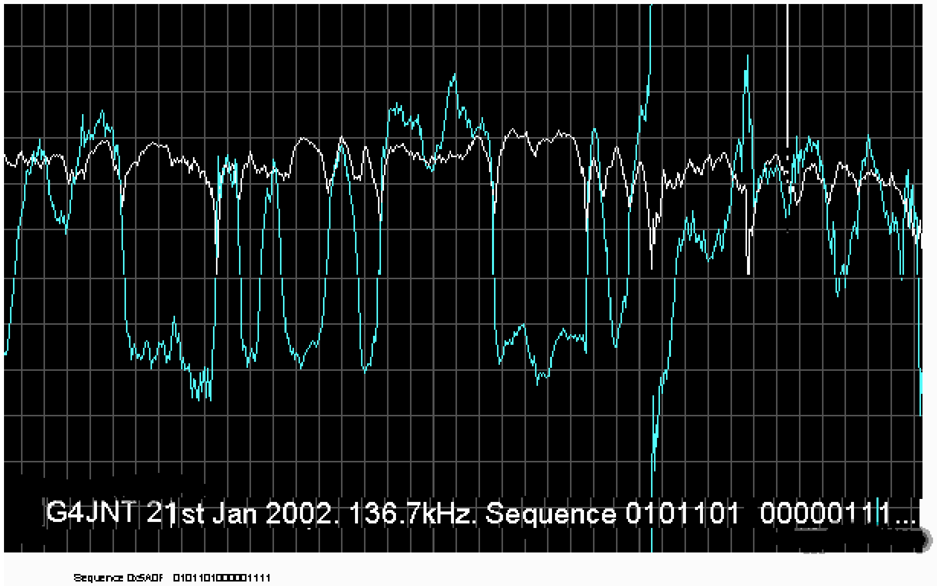
- Tests on 137kHz using 1 bit/second BPSK showed excellent results
  - As expected, having no need to recover symbol timing, very weak signalling was achieved from start up.
  - Good frequency stability was needed, sufficient to ensure the phase over the period of an over -
  - 90° in 30 minutes at 137kHz = 10^{-9} frequency stability - no great challenge.
  - We’d use a GPS locked source these days!

Coherent Signalling tests

Plain Carrier



BPSK Sequence



G4JNT > G3PLX GPS Locked signalling tests

HAD to use 136.71875kHz (5MHz * 7 / 256) to get exact carrier frequency from AD9851 DDS source

Interval 5MHz / 2^{32} = 1.16mHz = 1 cycle / 14 minutes

WSJT / JT65

- Slow signalling mode for EME and very weak VHF use.
- Needs accurate timing to within a few seconds
  - GPS timing is not essential, but would save having to keep the PC clock accurate
  - With GPS timing, could be used on beacons.

BEACONS

- IARU HF beacon chain
  - GPS controlled, multiple transmitters time-share a single frequency per band
- The UK 5MHz beacons are GPS timed.
- Next generation of VHF beacons will be GPS frequency and time controlled
  - Remove the uncertainties of frequency and timing when signal is very weak
  - Automatic monitoring when otherwise inaudible - DSP assisted

- Several Microwave beacons already frequency locked to a local reference.
- Some to GPS
  - GB3SCF 3400.90500000 MHz,
  - GB3SCX 10368.9050068 MHz
  - ± GPS jitter (a few Hz over tens of seconds)
  - Both use a DDS clocked from a simple GPSDO to give the source frequency for multiplication to microwaves
  - Others beacons on the site will follow.

Chirp Sounder Monitoring

– **ChirpStep By SM7ETW**

- **Will step your Icom receiver from 2 MHz to 30 MHz in 100 kHz steps in sync with an Ionosonde.**
- **Together with ChirpView 1.09 by G0TJZ you can make your own Ionograms.**
- **This is an Ionogram of the Inskip sounder in the UK made at my QTH on 27th march 2003 at 14.11Z**