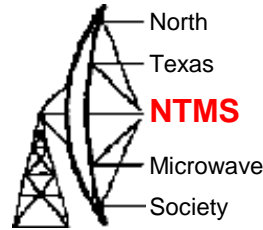North
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The Spectracom 8194B Ageless Master Oscillator part 2 + Tiny PFA measurements in TimeLab

Jim McMasters KM5PO

November 9th, 2024

Spectracom 8194B

- Highly accurate frequency source available in oven-stabilized crystal oscillator (OCXO) and Rubidium versions.

- Its outputs are locked to the United States Naval Observatory via the NAVSTAR Global Positioning System (GPS).

- Spectracom's field-proven Ageless Oscillator technology provides continual automatic frequency control.

- A long-term averaging algorithm compensates for oscillator aging and temperature drift.

- Units were available January 2024 from Jim McClellan at Cowtown Hamfest.

- Al Ward performed a modification which removed a factory mod and restored 10 MHz outputs.
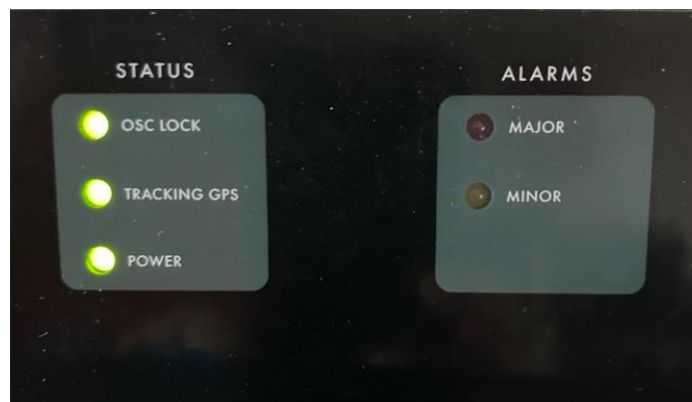
Spectracom 8194B
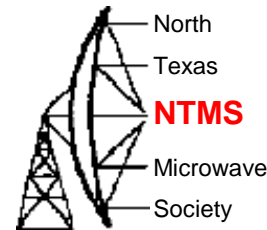
- Accuracy: Continuous self-calibration to GPS provides ± 1.0 x 10^{-11} frequency accuracy with the OCXO versions and ± 1.0 x 10^{-12} frequency accuracy for Rubidium version.

- Front panel
  - (1) 10 MHz output
  - (1) PPS output
    - Leading edge synchronized to UTC typically within ±30 nanoseconds with SA off and in Position Hold
  - (1) RS-232 Comm port

- Rear panel
  - (4) 10 MHz output
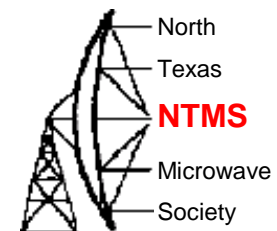 - (1) Data Clock Output (including disciplined 1 PPS)

Spectracom 8194B
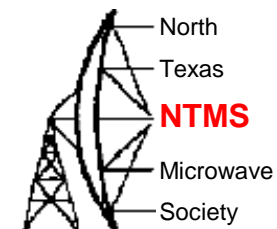
- Front panel of rack mounted instrument

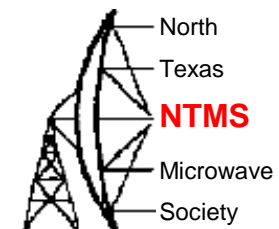

- Happy state – all green lights

Spectracom 8194B

- OCXO center, GPS receiver on the right
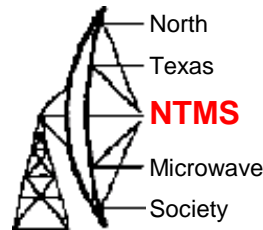
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Active GPS Antenna

- Provides 30 dB of gain and requires +5 VDC at 27 milliamps

RS232 Comms

- GSS, provides an instantaneous view of the GPS reception quality.

```
GSS Command

TRACKING 09 SATELLITES
GPS STATE= POS-HOLD  DOP= 00.0
LATITUDE= N 32 29 05.903 LONGITUDE= W 097 17 23.836 HEIGHT= +00220 METERS
QUALITY= PASSED
CHAN VID MODE STREN  STAT
 01  08   08   030   08A0
 02  28   08   042   08A0
 03  10   08   050   08A0
 04  32   08   052   08A0
 05  24   08   035   08A0
 06  27   08   037   08A0
 07  21   05   029   08A0
 08  00   00   000   0000
 09  18   08   029   09A0
 10  23   08   047   08A0
 11  00   00   000   0000
 12  00   00   000   0000
```

RS232 Comms
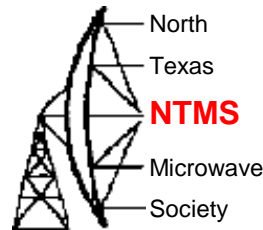
- DH, display tracking histogram. Determine long term reception quality

```
DDHH

TIME=11:00:00 DATE=2024-11-09    5 am Local
 0=00000    1=00000    2=00000    3=00000    4=00884
 5=01391    6=01325    7=00000    8=00000    9=00000
10=00000   11=00000   12=00000    Q=03600

TIME=12:00:00 DATE=2024-11-09
 0=00000    1=00000    2=00000    3=00000    4=00187
 5=01620    6=01726    7=00067    8=00000    9=00000
10=00000   11=00000   12=00000    Q=03600

TIME=13:00:00 DATE=2024-11-09
 0=00000    1=00000    2=00000    3=00000    4=00007
 5=00836    6=01979    7=00778    8=00000    9=00000
10=00000   11=00000   12=00000    Q=03600

TIME=14:00:00 DATE=2024-11-09
 0=00000    1=00000    2=00000    3=00001    4=00258
 5=01336    6=01973    7=00032    8=00000    9=00000
10=00000   11=00000   12=00000    Q=03599

TIME=14:22:48 DATE=2024-11-09
 0=00000    1=00000    2=00000    3=00066    4=01021
 5=00255    6=00025    7=00000    8=00000    9=00000
10=00000   11=00000   12=00000    Q=01301

END OF LOG
```
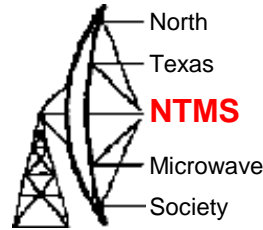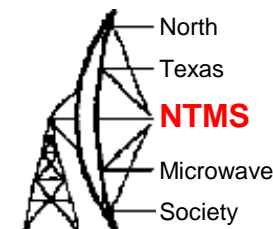
RS232 Comms

DAL Command (Display Alarm Log)

```
   TIME= 14:45:21 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.0>
COOLING FAN= OFF
ALARM RELAYS: MAJOR= OFF MINOR= OFF
ACTIVE ALARMS: NONE
   TIME= 14:54:13 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.0>
COOLING FAN= OFF     8:54 am Local
ALARM RELAYS: MAJOR= OFF MINOR= ON
ACTIVE ALARMS: MINOR
TRACKING ALARM 1
   TIME= 15:00:00 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.0>
COOLING FAN= OFF    9:00 am Local
ALARM RELAYS: MAJOR= OFF MINOR= ON
ACTIVE ALARMS: MINOR
TRACKING ALARM 1
LOW GPS QUALITY
   TIME= 15:04:32 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.0>
COOLING FAN= OFF
ALARM RELAYS: MAJOR= OFF MINOR= ON
ACTIVE ALARMS: MINOR
LOW GPS QUALITY
   TIME= 16:00:00 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.0>
COOLING FAN= OFF
ALARM RELAYS: MAJOR= OFF MINOR= OFF
ACTIVE ALARMS: NONE
   TIME= 17:12:57 DATE= 2024-11-07 STATUS CHANGE <TEMP= +42.5>
COOLING FAN= OFF
ALARM RELAYS: MAJOR= OFF MINOR= OFF
ACTIVE ALARMS: NONE
```

RS232 Comms

- ## DOL Command (Display Oscillator Log)

SPECTRACOM CORPORATION GPS DISCIPLINED OSCILLATOR
SOFTWARE VERSION 3.03 DATE: MARCH 22, 2005 08:56:39
UNIT STARTED 19:25:45 2024-09-13
BAUD GENERATOR 1 = VERSION 0.00
BAUD GENERATOR 2 = VERSION 2.02
BAUD GENERATOR 3 = VERSION 0.00
GPS RECEIVER = 12 CHANNEL M12 VERSION 2

  TIME= 13:10:17 DATE= 2024-11-09 D/A= D8F0(84%) FREQ ERROR= +1.00E-10
LONG GATE 10MHZ OFFSET= NONE   INTERNAL TEMP= +41.5
FREQ CNT= {NUL}{NUL}{NUL}{NUL}{NUL}10,000,000,001

  TIME= 13:13:25 DATE= 2024-11-09 PHASE ADJUSTMENT
AVG LEN= 0168 TOTAL= FFFFE771
DAC= D8F0(84%) TEMPERATURE= +41.5
PHASE ERROR= -008.73 nSEC

RS232 Comms
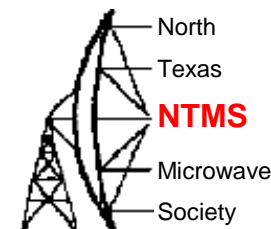
- DOL Command continued

- Phase adjustment:

  - Occur every 6 minutes for OCXO units. (Model 8194B and 8195B)
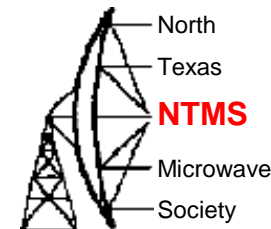
```
 TIME= 13:19:25 DATE= 2024-11-09 PHASE ADJUSTMENT
AVG LEN= 0168 TOTAL= FFFFE889
DAC= D8F0(84%) TEMPERATURE= +41.5
PHASE ERROR= -008.34 nSEC


 TIME= 13:25:25 DATE= 2024-11-09 PHASE ADJUSTMENT
AVG LEN= 0168 TOTAL= FFFFE7E8
DAC= D8F0(84%) TEMPERATURE= +41.5
PHASE ERROR= -008.56 nSEC


TIME= 13:26:59 DATE= 2024-11-09 D/A= D8F0(84%) FREQ ERROR= +0.00E-10
LONG  GATE 10MHZ OFFSET= NONE   INTERNAL TEMP= +41.5
FREQ CNT= {NUL}{NUL}{NUL}{NUL}{NUL}10,000,000,000


 TIME= 13:31:25 DATE= 2024-11-09 PHASE ADJUSTMENT
AVG LEN= 0168 TOTAL= FFFFD8FF
DAC= D8F0(84%) TEMPERATURE= +41.5
PHASE ERROR= -013.86 nSEC
```

RS232 Comms

- ### DOL Command continued

- ### Phase adjustment:

  - Occur every 6 minutes for OCXO units. (Model 8194B and 8195B)

```
 TIME= 14:07:37 DATE= 2024-11-09 3D FIX ACQUIRED
LATITUDE= N 32 29 05.903 LONGITUDE= W 097 17 23.836 HEIGHT= +00220 METERS

 TIME= 14:13:27 DATE= 2024-11-09 PHASE ADJUSTMENT
AVG LEN= 0168 TOTAL= 00004167
DAC= D8F2(84%) TEMPERATURE= +42.0
PHASE ERROR= +023.25 nSEC

 TIME= 14:14:28 DATE= 2024-11-09 3D FIX ACQUIRED
LATITUDE= N 32 29 05.903 LONGITUDE= W 097 17 23.836 HEIGHT= +00220 METERS

 TIME= 14:17:05 DATE= 2024-11-09 D/A= D8F2(84%) FREQ ERROR= +0.00E-10
LONG  GATE 10MHZ OFFSET= NONE   INTERNAL TEMP= +42.0
FREQ CNT= {NUL}{NUL}{NUL}{NUL}{NUL}10,000,000,000

 TIME= 14:18:14 DATE= 2024-11-09 3D FIX ACQUIRED
LATITUDE= N 32 29 05.903 LONGITUDE= W 097 17 23.836 HEIGHT= +00220 METERS
```
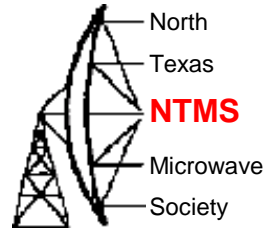
Testing

- An insulated container was used to house both the TinyPFA and the OCXO or DUT. All OCXOs tested reached a temperature of ~ 105 F in one hour.

- The DUT was allowed a 15 minute warmup and then tested for a one hour period.

- Test 1 consisted of measuring the phase/frequency difference between the DUT to the TinyPFA pll. The pll value was nulled prior to each test. The results were varied and not real useful.

- Then each OCXO was netted (modification made when needed) as close as possible using the Ageless as the gold standard.

- Test 2 - each OCXO was measured against the Ageless Spectracon.

Cheap OCXOs
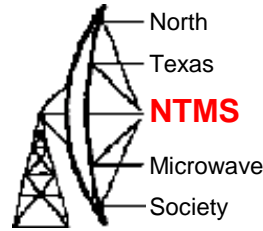
- Used CT1 OSC5A2BO OCXO are available on Amazon and auction sites that come with supporting power supply components

- These have been removed from decommissioned GSM/UMTS base stations.

- This voltage controlled OCXO has an input for a 0 to 4V tuning voltage when new.

- Because of aging, the tuning voltage to reach 10 MHz is a bit different for each OCXO specimen.
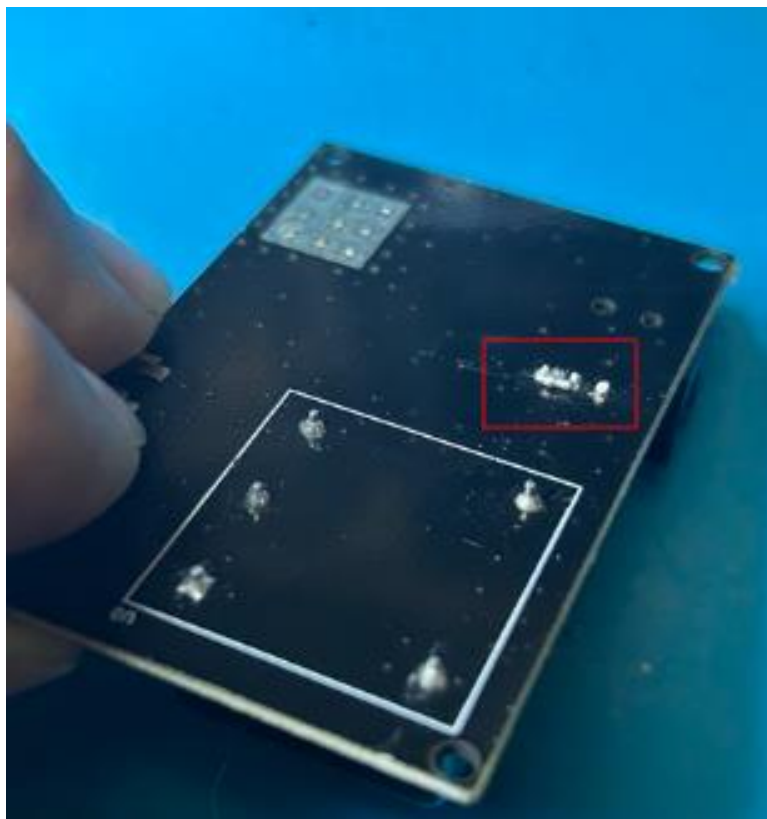
Mods/fixes
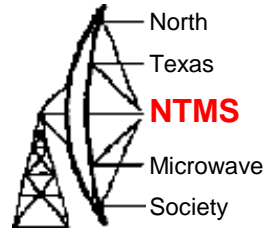
- Check that the SMA connectors are soldered

- Check that the CERMET pot is soldered (3 legs)

- One side of the pot is tied to center per schematic.This was open on one of my specimens.

- Bridge over R3, Vtune range = 0V to 2.1V

- Remove R1, Bridge over R3, Vtune range = 0V to 2.5V

Mods/fixes
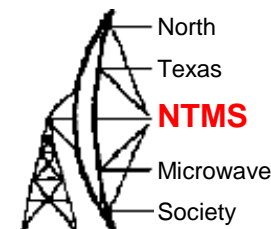
- Check pot legs and continuity between two inboard legs

OCXO spec

OSC5A2B02

Item	Spec	Parameter value	Test conditions
1	Ageing	+/- 100 PPB/1st Yr +/- 0.4 PPM/10 Yrs	@ 25 C after 30 days power on
2	Temperature stability	+/- 10 PPB	0 C to + 75 C, ref to +25 C
3	Short-term stability	< 0.05 PPB/s	1 hour after power-on
4	Working current	< 600mA initial < 250mA steady state	
5	Voltage control range	2.0 +/- 2.0 V	

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Mods

Mod 1 - jump R3
Mod 2 - open R1
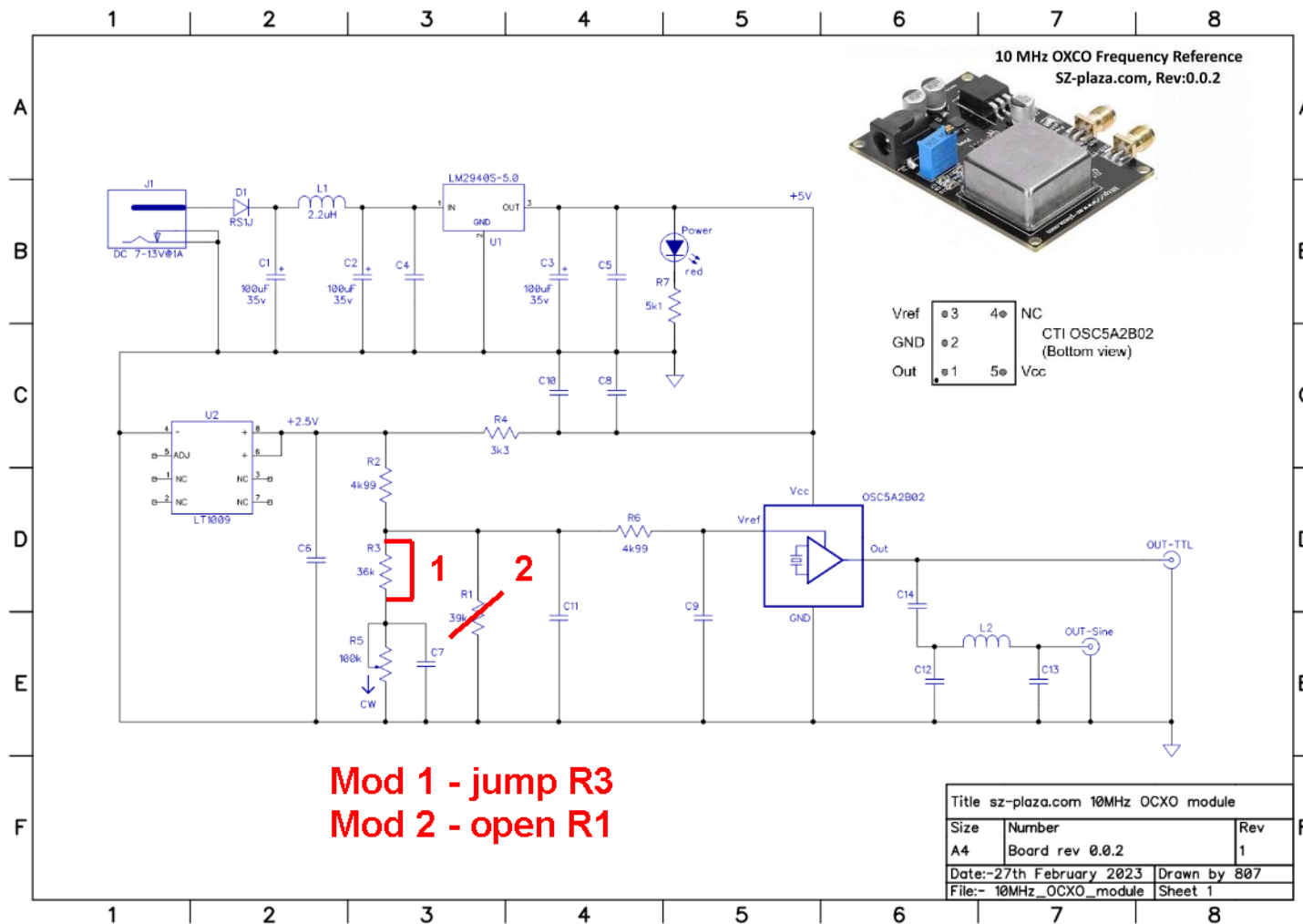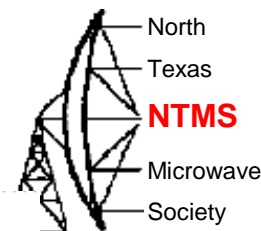
Testing
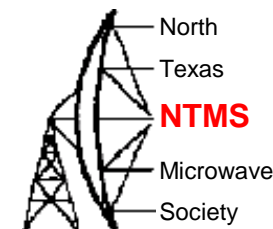
- In Test 1 the Spectracon Ageless was measured against (by) the Tiny PFA PLL. Variances are in the sub milli-hertz area and more likely to be from the Tiny PFA PLL. This was possibly the best use of Test 1
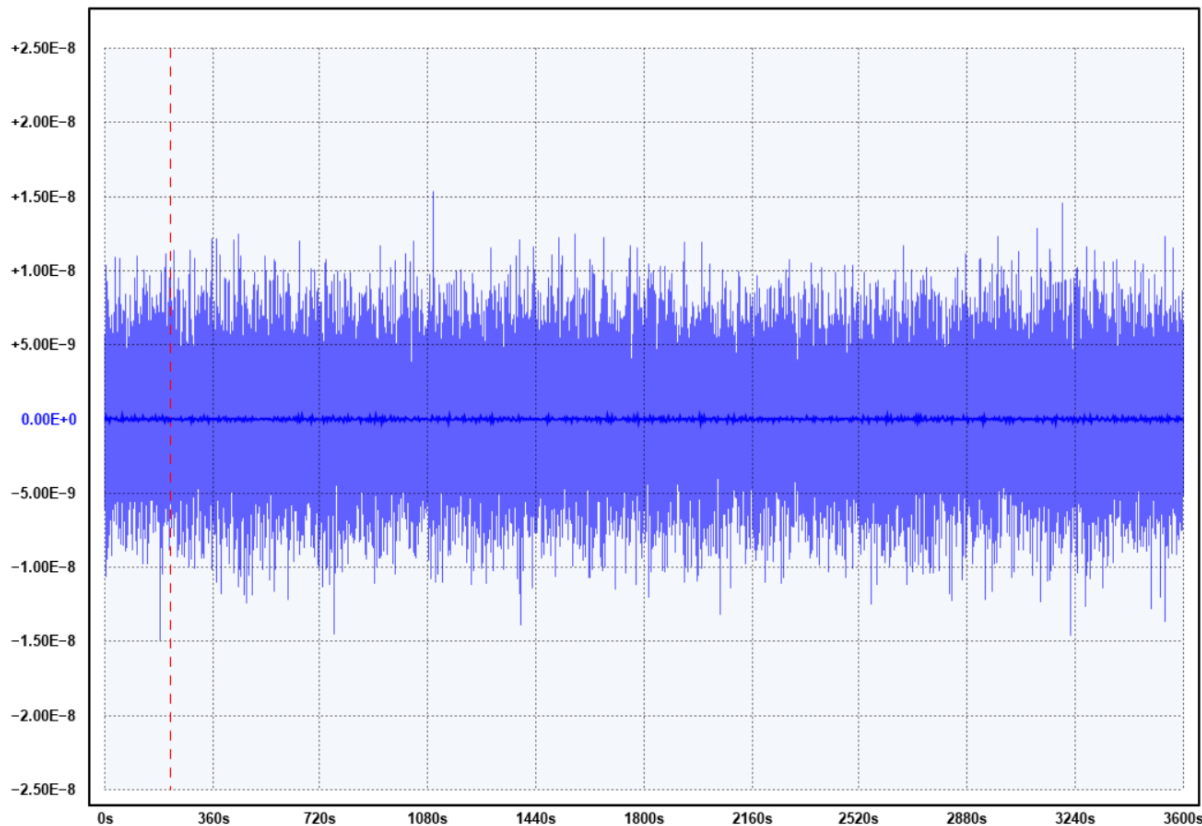
Origin	Drift (Hz/sec)	Drift (Hz/hr)
+4.14E−13	−2.32E−9	−8.35E−6

Avg Time (s)	Freq (Hz) at 3600s	Error
0.1	9 999 999.969 111 091	−3.09E−9
0.3	10 000 000.000 173 250	+1.73E−11
1	9 999 999.997 291 386	−2.71E−10
3	9 999 999.998 458 812	−1.54E−10
10	9 999 999.999 958 023	−4.20E−12
30	10 000 000.000 081 675	+8.17E−12
100	10 000 000.000 001 766	+1.77E−13
300	10 000 000.000 007 620	+7.62E−13
1 000	9 999 999.999 996 757	−3.24E−13
3 000	9 999 999.999 999 732	−2.68E−14

Testing

Spectracon Ageless was measured against the Tiny PFA

Testing
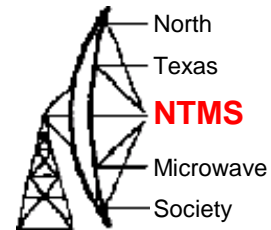
- In Test 2 Leo Bodnar GPS against Spectracon

Origin	Drift (Hz/sec)	Drift (Hz/hr)
+6.63E−11	−2.19E−7	−7.90E−4

Avg Time (s)	Freq (Hz) at 3600s	Error
0.1	9 999 999.999 900 000	−1.00E−11
0.3	10 000 000.000 133 334	+1.33E−11
1	9 999 999.999 960 000	−4.00E−12
3	9 999 999.999 870 000	−1.30E−11
10	9 999 999.999 737 000	−2.63E−11
30	9 999 999.999 833 666	−1.66E−11
100	9 999 999.999 871 301	−1.29E−11
300	9 999 999.999 980 601	−1.94E−12
1 000	10 000 000.000 189 031	+1.89E−11
3 000	10 000 000.000 144 834	+1.45E−11

Testing

Leo Bodnar measured against Ageless Spectracon

Testing

- In Test 2 Best of the Amazon OCXO against Ageless Spectracon

Origin	Drift (Hz/sec)	Drift (Hz/min)
+2.67E−10	+3.72E−6	+2.23E−4

Avg Time (s)	Freq (Hz) at 1757s	Error
0.1	10 000 000.008 500 000	+8.50E−10
0.3	10 000 000.008 466 667	+8.47E−10
1	10 000 000.008 430 000	+8.43E−10
3	10 000 000.008 496 666	+8.50E−10
10	10 000 000.008 445 000	+8.45E−10
30	10 000 000.008 347 001	+8.35E−10
100	10 000 000.008 206 300	+8.21E−10
300	10 000 000.008 279 333	+8.28E−10
1 000	10 000 000.007 541 370	+7.54E−10

LBE-1420 GPSDO
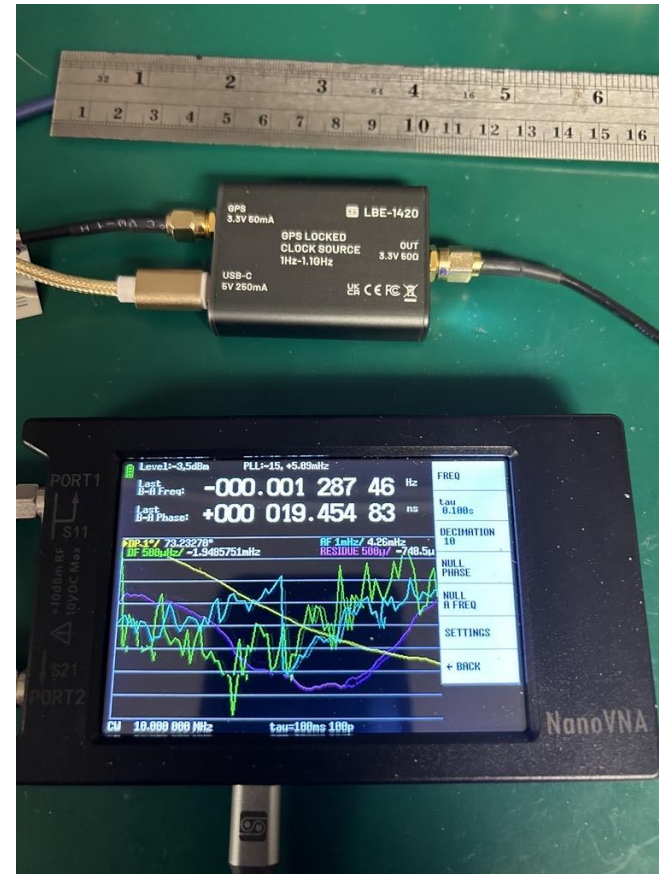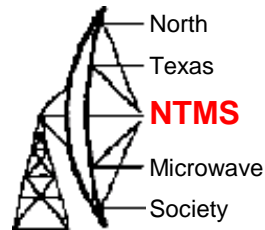
LBE-1420 GPSDO locked clock source : Leo Bodnar Electronics

LBE-1420 GPSDO
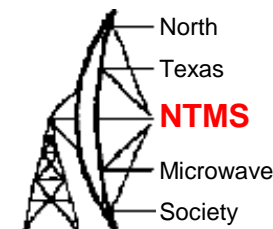
LBE-1420 GPS locked clock source diagnostics

Serial number: 0673ED10312D

Hardware firmware version: 1.05, new version 1.06 available at https://www.leobodnar.com/files/firmware-doctor.exe

Configuration software version: 1.05, new version 1.06 available at https://www.leobodnar.com/files/LBE-1420-Configuration-v1.06.exe

Operating system: Windows 11 (v10.0.22621)

Output frequency: 10000000Hz

Number of satellites: 14

Average satellite signal strength C/No: 34dB
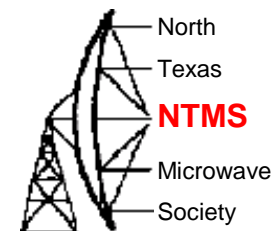
Approximate coordinates (to nearest 10km):

Latitude: 32.5°

Longitude: -97.3°

Altitude: 227m

Product and support page on leobodnar.com

Reference

- Schematic and mods detail: Cheap chinese 10 MHz OCXO Frequency Reference Modules - Page 1

Questions?

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