A new 1PPS Time / frequency interface

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1PPS issues and solutions

In-station time interfaces are limited to PTP, NTP and latterly G.703 1PPS.

PTP is the only interface that can give accuracies in the ns-µs range but suffers due to being a data interface.

Using this between equipment can be a problem due to security constraints between networks and expensive where Ethernet switches and routers have to be PTP aware.

A new interface is required that addresses this with nanosecond accuracy

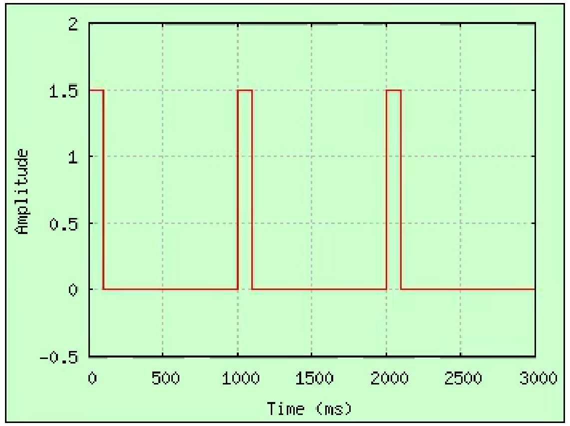
Yet another physical interface

- The world really needs a yet another new physical interface. It must be at 3 days since the last one
- So can we get new features on an old one
- If we put our minds to it
- *Yes!*

- *Contributed at ITU SG15.Q13 18-22 March 2019 WD13-11*

Need for 1PPS Time interface

- 1PPS not that accurate (Slow rise time)
- Suffers from Skin effect in cables
- Does not convey time information
- No Auxiliary data
- Short range only
- Found everywhere
- Well understood
- No link security concerns

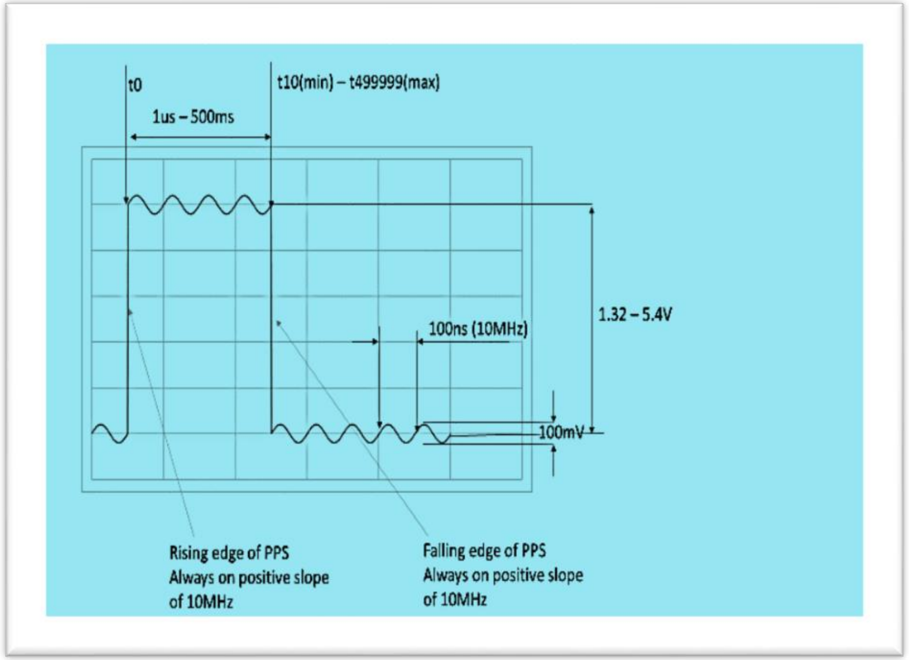


Features

- Backward compatible with ITU G.703 19.1 interface.
- Adds “Frequency Perfect” frequency transfer
- Adds Improved Phase accuracy
- Immune to cable Skin effect – Only the 10MHz matters
- Adds time-of day
- Adds delay data channel
- Increased distance > 100M (tbd)
- No internetwork security concerns – No IP, Ethernet or bridgeing

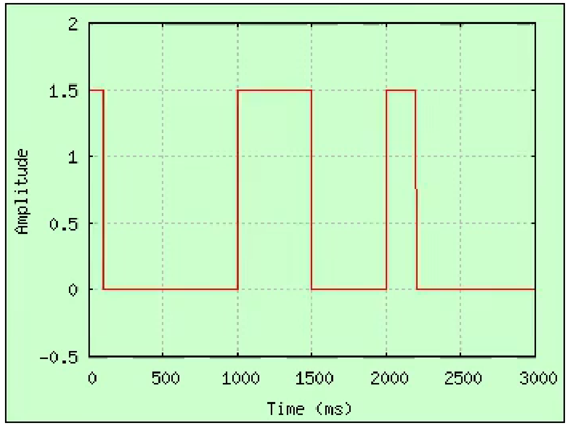
Method

- Superimpose 10MHz on the 1PPS
- 100mv Sine (Or Square) wave is still compliant with ITU G.703
- 1PPS edge now identifies which 10MHz cycle is the second epoch
- All timing now from the stable 10MHz



Data channel

- Width of pulses modulate to convey data
- Rising edge is still the PPS epoch
- Still compliant with G.703
  - 100ns – 500ms
  - With 100ns/bit gives 18bits equivalent/second



Data channel contents

- Time of day (UTC, but could be any timescale)
- Leap second announce (At end of current day)
- Leap Second announce (At end of current month)
- Date
- TAI-UTC
- Round trip delay (Automatic or manual)
- User defined Channel (5 timeslots)
- Clock ID
- User ID
- Clock Source
- Clock Status

Data channel contents

Second of minute	Application	Pulse width Definition
55 to 10	Time of Day	1us + (Second of day * 100ns)
53	Leap Second announcement for end of current day (Must agree with 54 if used)	1us (not used) 1us + 100ns (No leap second due) 1us + 200ns (positive leap second) 1us + 300ns (negative leap second)
54	Leap Second announcement for end of current month (Must agree with 53 if used)	1us (not used) 1us + 100ns (No leap second due) 1us + 200ns (positive leap second) 1us + 300ns (negative leap second)
11	Day of month (1 – 31)	1us + Day of month * 100ns
12	Month (1 - 12)	1us + Month * 100ns
13	Year	1us + Year * 100ns
14	TAI – UTC (seconds)	1us + (TAI – UTC) * 100ns
15 – 19	User defined (default or unused = 0)	1us + (User defined value) * 100ns
20	Round trip delay scale	1us + 100 ns (for nanoseconds) 1us + 200ns (for pico-seconds)
30	Round trip delay scale	Repeat of 20 above
40	Round trip delay scale	Repeat of 20 above
21	Round trip delay	1us + (delay in scale units * 100ns)

Second of minute	Application	Pulse width Definition
22 - 29	User defined (default or unused = 0)	1us + (User defined value) * 100ns
31	Round trip delay	Repeat of 21 above
41	Round trip delay	Repeat of 21 above
14	ClockID(Number only)	1us + ClockID * 100ns
15	UserID(Number only)	1us + UserID * 100ns
16	ClockSrc (See table 2)	1us + ClockSrc * 100ns
22	Clock Status (See table 3)	1us + Status * 100ns
32	Clock Status (See table 3)	1us + Status * 100ns
42	Clock Status (See table 3)	1us + Status * 100ns

Frame alignment is achieved by watching for the monotonic increase of the zero to 10 second markers. The 55 to zero markers should not be used as there may be 59, 60 or 61 seconds in a minute. Seconds 55 to zero can be used for observing and recording leap second events. Advertised leap seconds should be taken account of in the frame alignment process.

Note: Slowly changes items such as the date may be compared minute by minute. Any errors are therefore simply detected. Items such as Clock Status, that can change minute by minute are repeated three times at 10 second intervals

- Time of day
- Leap second announce (day)
- Leap Second announce (month)
- Date
- TAI-UTC
- Round trip delay
- User defined Channel
- Clock ID
- User ID
- Clock Source
- Clock Status

Clock Source

Clock Source	Value	Information
Unknown	0	No clock source information
PRC	1	PRC G.8xxx. Frequency source only. Time unqualified
SSU	2	SSU G.8xxx . Degraded PRC source
SEC	3	SEC
ePRTC	4	
GNSS(multi)	10	GNSS receiver tracking multiple constellations. UTC
GPS	11	GPS(UTC)
Galileo	12	Galileo(UTC)
GLONASS	13	Glonass(UTC)
BeiDou	14	BeiDou(UTC)
Local	15	“Other” clock source
MSF	16	MSF(UK)
DCF	17	DCF(D)
WWVB	18	NIST (Fort Collins)
LW	19	Other LW system e.g eLoran

- A Range of common clock sources is proposed
- Plenty of scope for expanding table if required

Clock Quality

Clock Status	Value	Information
Unknown	0	No status information
Good	1	No alarms
Source bad - Holdover	2	Loss of clock source – in holdover (Class G.8xx)
Source bad - Free run	3	Loss of clock source – in free run (or start-up)
Source bad – DNU	4	Failure – Do not use

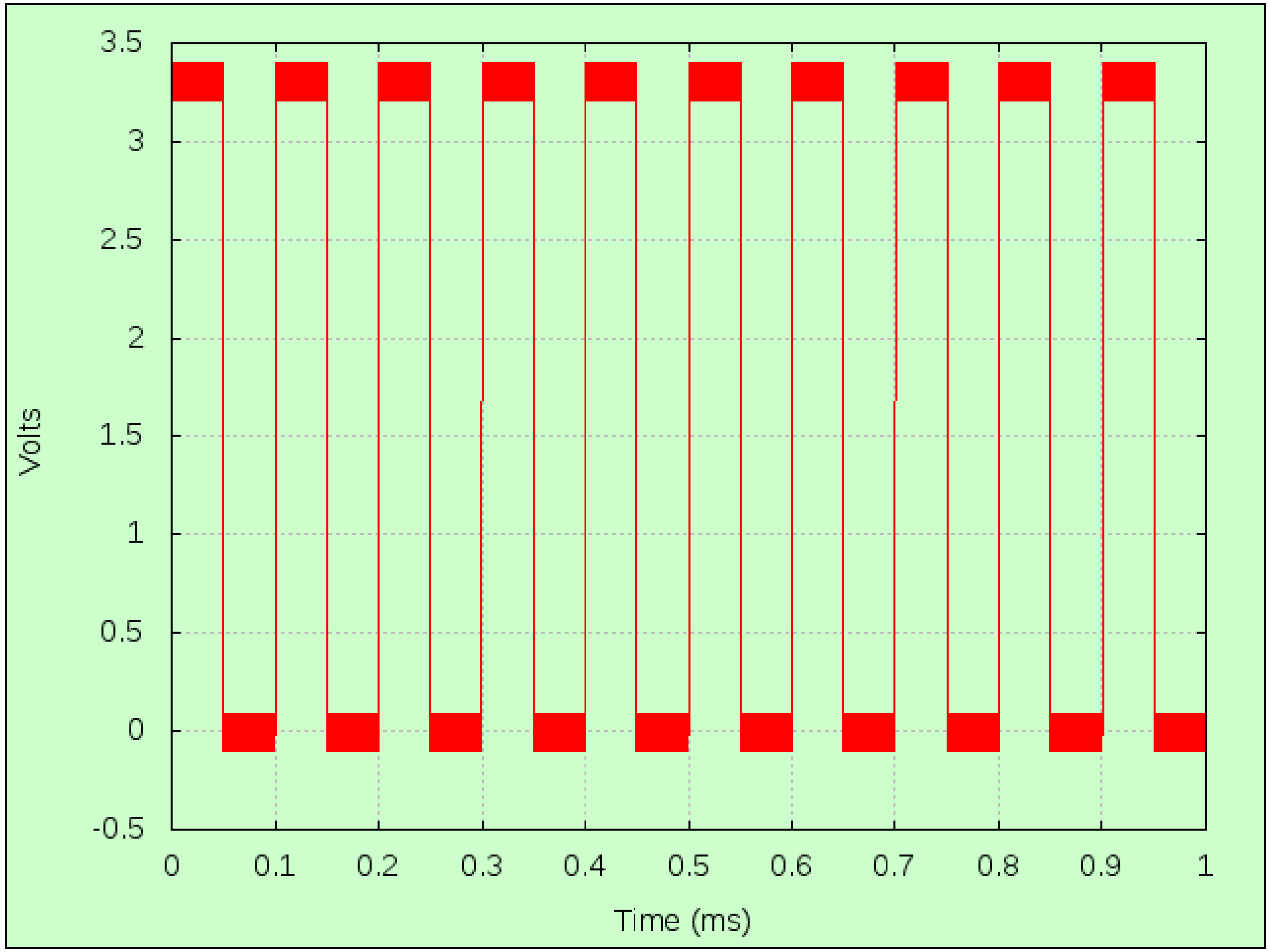
- Standard “Telecoms” qualities proposed
- Plenty of scope for expanding table if required

Applications

- Laboratory time & frequency distribution
- Inter-network time & frequency distribution
- Cell site time distribution
- Time Transfer in IP free environments

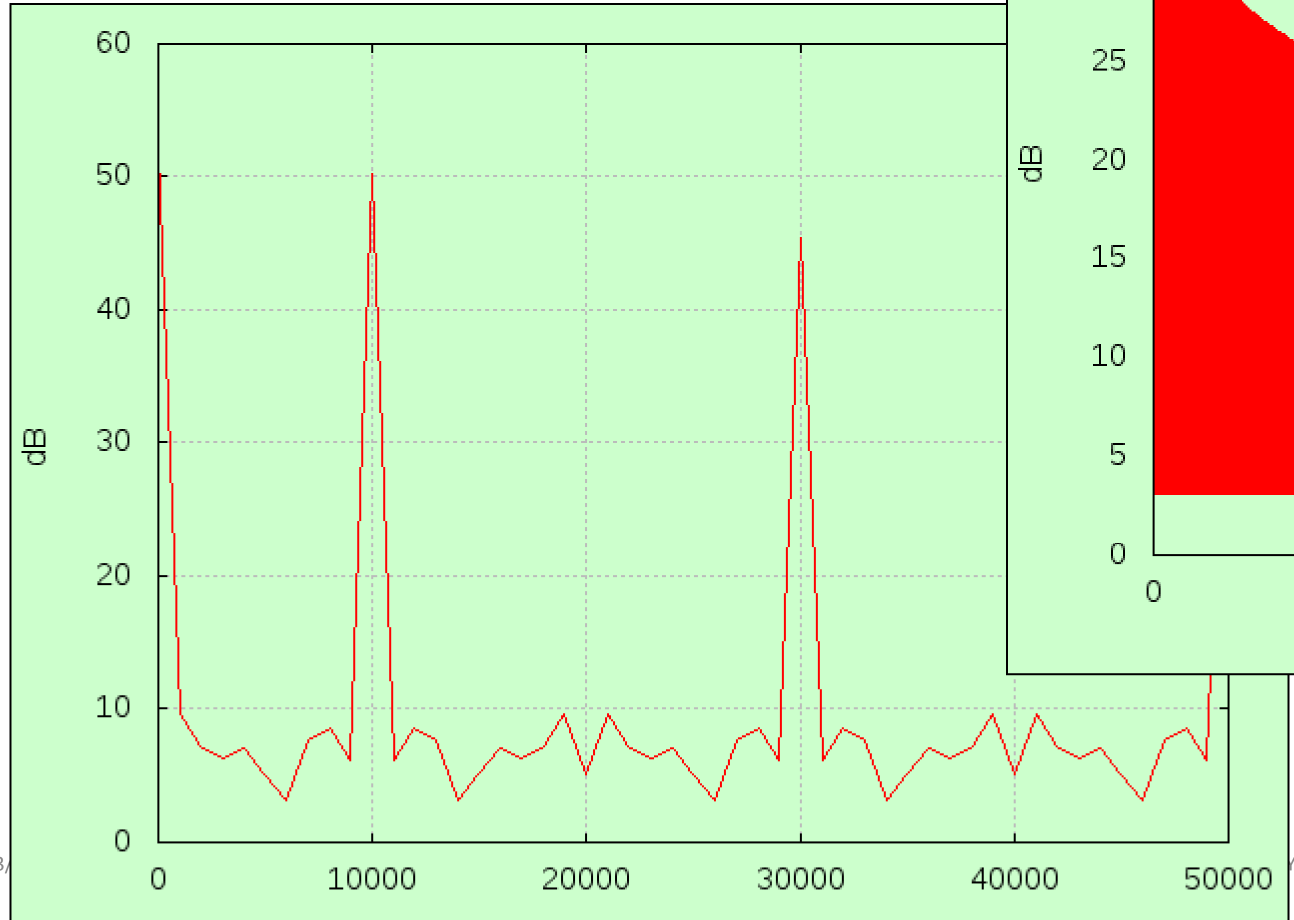
Simulation

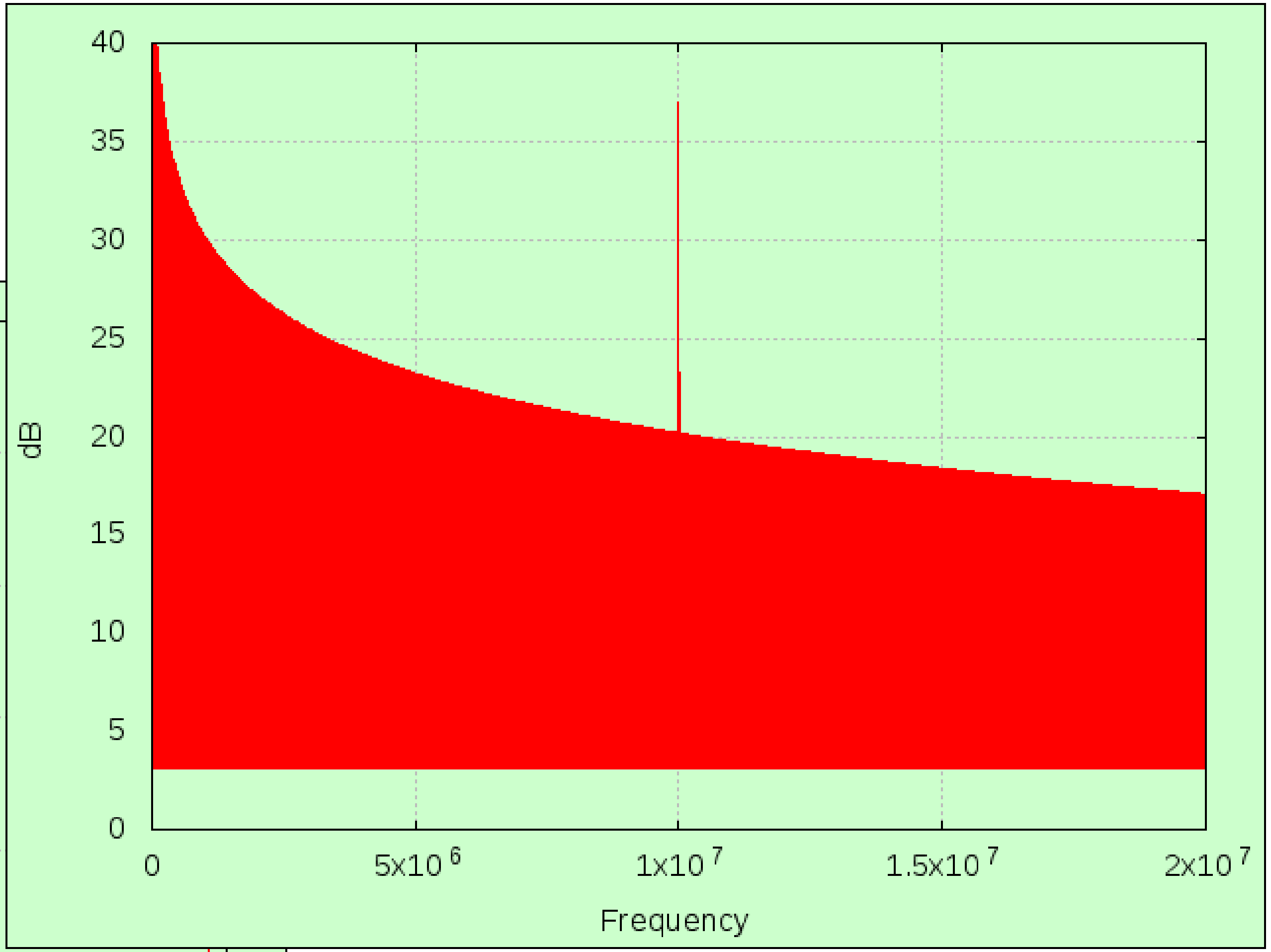
- Not practical (impossible) to produce FFT of 1Hz signal on a 10MHz clock
- Here a 10KHz Square wave is added to a 10MHz signal before processing in a 100000 point FFT
  - fftw library can do this!



Simulation

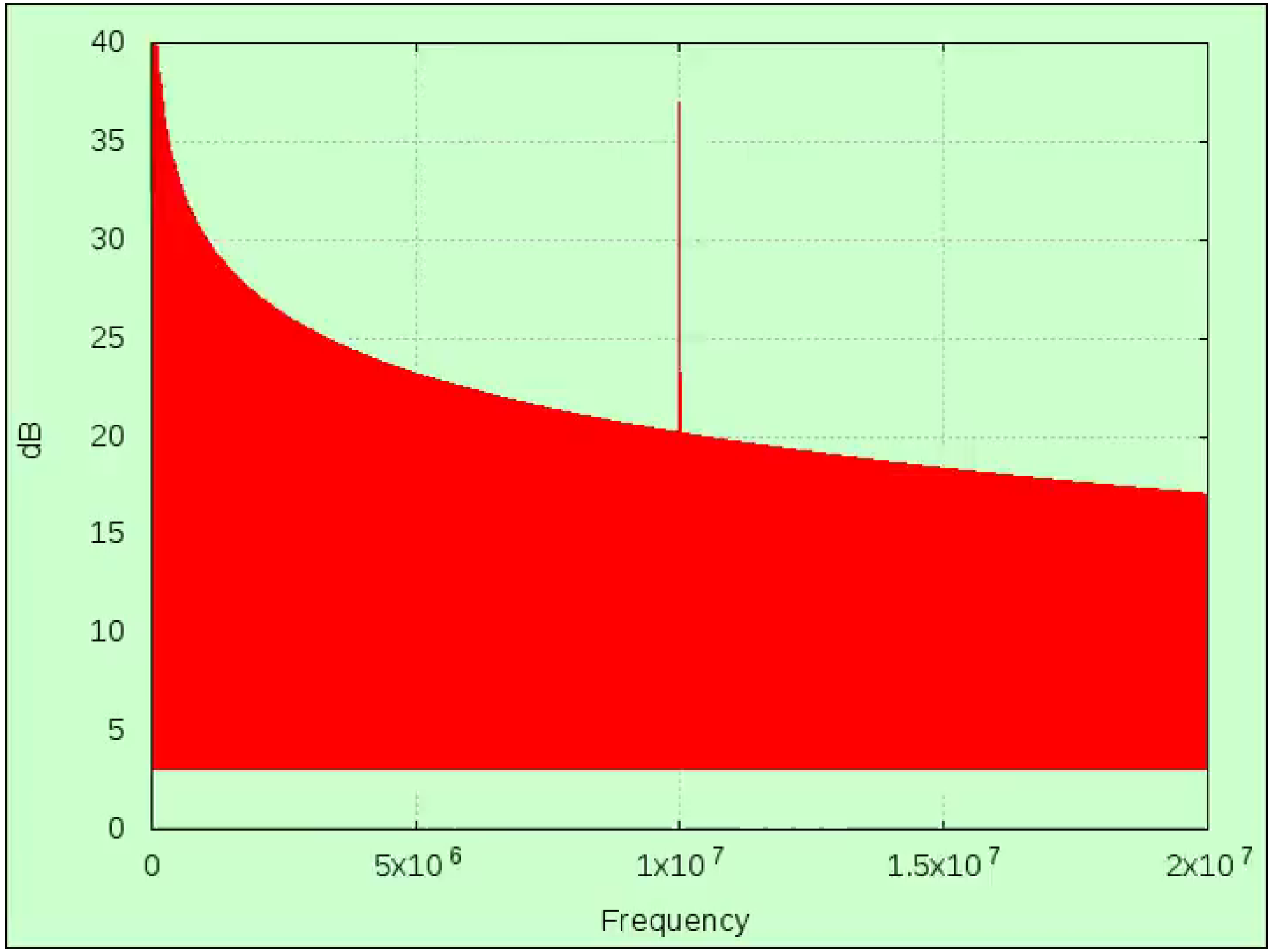
- Result not surprising





Simulation

- Zooming in shows good noise margin around 10MHz
- Noise would be much less at 1PPS, though frequency analysis may not be the best tool at this point.



Measured

- No measured results yet
  - Initial results will be presented at ITSF in November

ITU

- *Contributed at ITU SG15.Q13*
  18-22 March 2019 WD13-11

- *Has been put on the "Living List" for G.8271 :-*

"Time and phase synchronization aspects of telecommunication networks"

- *We will follow up with a more detailed contribution with test results.*

Summary

- *Improved accuracy 1PPS for Phase*
- *Time Transfer*
- *Delay compensation channel built in*
- *No data transfer security concerns*
- *Extended reach*
- *Simple implementation*
- *Under study for inclusion in G.8271 at ITU*
- *Much simpler that PTP/NTP type solutions*
- *Ideal for In-Building or On Mast solutions*

Thank you for listening