The Care And Feeding

Of a Network Timing and Synchronization Lab

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Presentation

- Presenter

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Audience

This presentation is aimed at three audiences:

1. Newcomers to the overall arena of LAN based sync technology testing
2. Persons who are building new test lab facilities
3. Organizations wishing to improve their existing lab

Goals

- To objectively share best practices encountered during three years of visiting multiple LAN sync labs on three continents

- To have a majority of reviewers comment “gee, I never thought of that before” at least once

Timing Lab Standard Signals

- 10 MHz
  - A distribution amplifier is often needed
- 1 PPS
  - A typical RG-58 type coaxial cable has capacitance of approximately 28 picofarads (pF) per foot. Therefore, even a relatively short cable of this type can adversely affect the integrity of the 1PPS signal rise-time
  - Take special care to avoid reflections (no Ts, poor terminations & connectors)
- Time-Of-Day
  - Several data formats … NMEA-0183, CMCC, ISO 8601, Cisco
  - Interface often EIA-422 or -485, sometimes EIA-232
- GPS
  - L1 signal; 1575.42 MHz

From the Roof, and Down

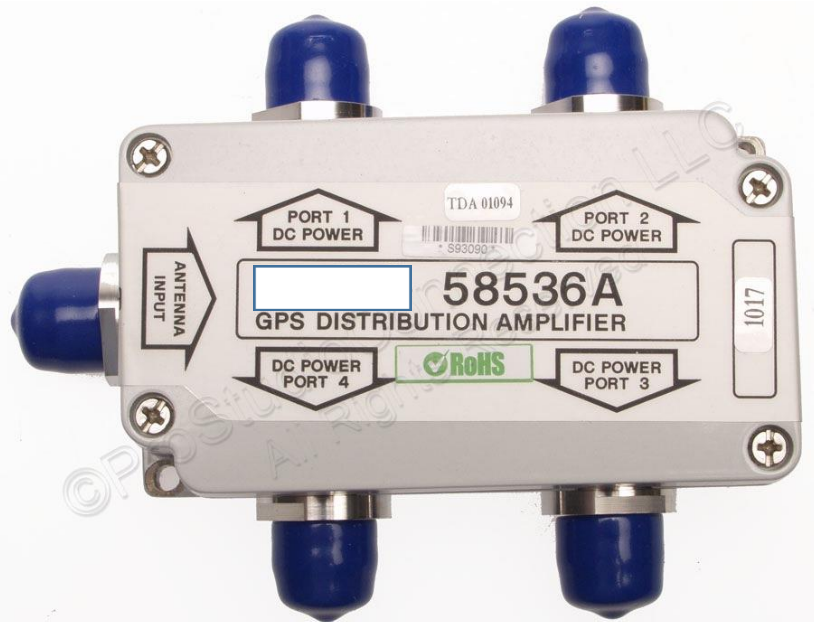
- GPS antenna
  - Antenna usually contains a DC powered preamplifier
- Cable
  - Ideally suited for low loss at 1.5 GHz; cable to be *of known length*
- GPS Distribution amplifier
  - Provides DC power to the antenna and multiple outputs for receivers
- More cable
  - Connects GPS receivers to distribution amplifier
  - To be *of known length*

Cable "Of Known Length"

- A major theme of this presentation
- A frequent cause of heartburn in labs missing this key knowledge
- Has caused more testing "do overs" than any other single issue

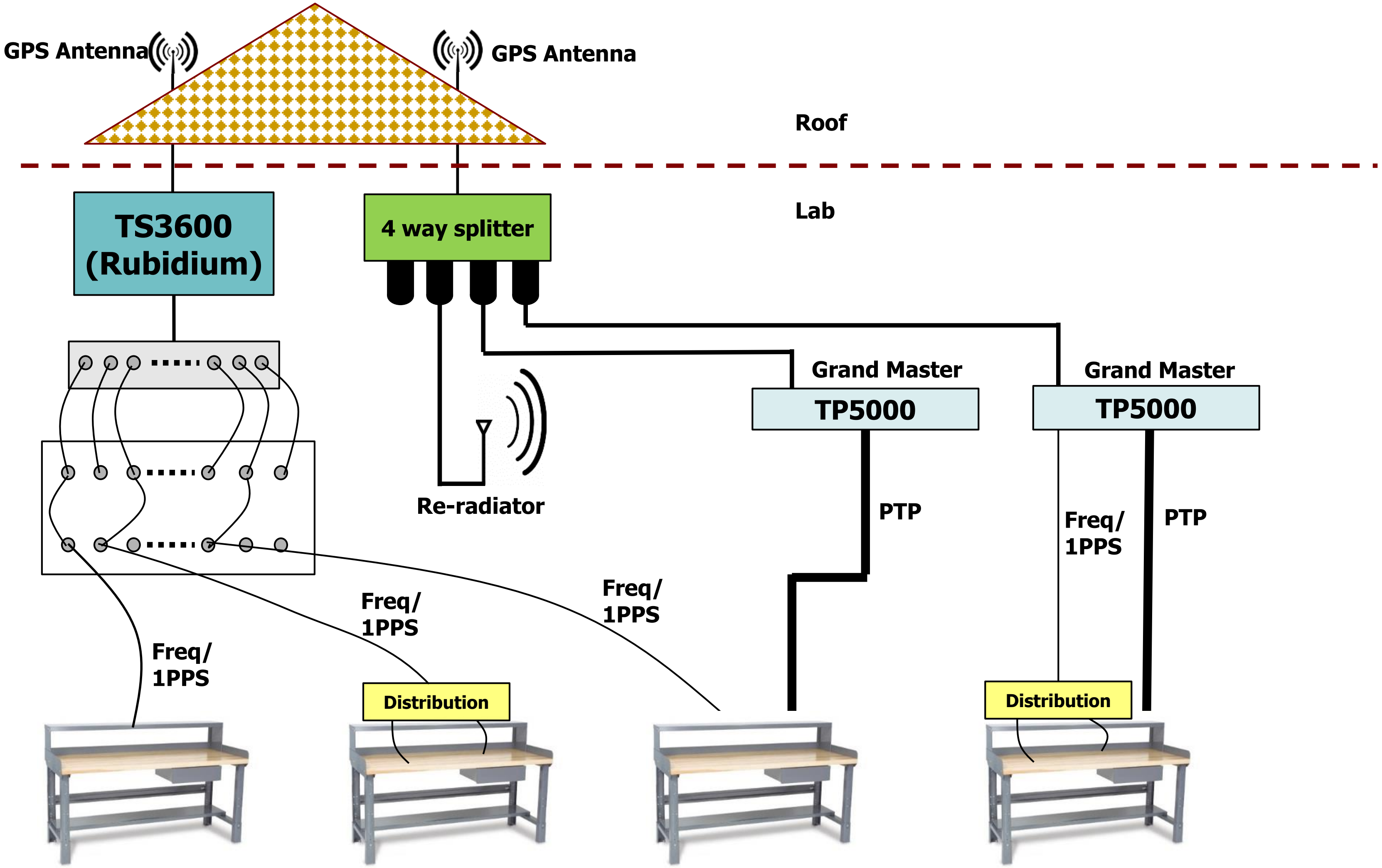
Your Cables Are Not Free Space

Sharing The Goodness



- GPS distribution amplifier
- Application shown in next slide
- This is a ‘cable’ also … it’s equivalent to about 8 meters of added cable length, each port.

Sync Distribution



GPS: Notes, Challenges and Good Practice

- Each GPS feed has a length of low loss coaxial cable, the electrical length of which must be accounted for
- Using modern, sensitive GPS receivers in the lab may give multiple paths, via the re-radiator or the cable. *This must be monitored*.
- Often, a purpose built multicoupler is used for signal sharing
- GPS technology locates (and determines time) at the *antenna*, not at your receiver

Quiz: What is the problem in the picture on the previous slide?

GPS: Notes, Challenges and Good Practice

- Antennas offer the simultaneous challenges of needing to be powered, of being a known electrical distance from the receiver, and to keep any roof penetrations sealed against water incursion

[Antenna/cable show-and-tell]

Cabling: Velocity is the Factor

	50MHz Att/P	144MHz Att/P	432MHz Att/P	1296MHz Att/P	D	VF
Aircom+		4.5 / 1000	8.2 / 530	14.5 / 300	10.8	0.85
Aircell 7	4.8 / 1000	7.9 / 800	14.1 / -	26.1 / 190	7.3	0.83
Ecoflex 10		4.8 / 950	8.9 / -	16.5 / -	10.2	0.86
Ecoflex 15	1.96 / -	3.4 / 1800	6.1 / -	11.4 / -	14.6	0.86
H 100	2.8 / -	4.9 / 1000	8.8 / 530	16.0 / 130	9.8	0.84
H 155	6.5 / -	11.2 / 240	19.8 / 90	34.9 / 49	5.4	0.79
H 500	2.9 / -	- / 1000	- / 530	17.4 / 130	9.8	0.81
H 2000 flex	2.7 / -	4.8 / 1600	8.5 / -	15.7 / -	10.3	0.83
RG 55		18.5 / 300	34.0 / 200	60.0 / 100	5.4	0.66
RG 58 CU	11.0 / -	20.0 / 240	40.0 / 90	90.0 / 49	5.0	0.66
RG 174 U		34.0 / 95	60.0 / -	110.0 / 30	2.8	0.66
RG 213 U	4.3 / -	8.2 / 800	15.0 / 290	26.0 / -	10.3	0.66
RG 223 U		18.5 / 300	34.0 / 200	60.0 / 100	5.4	0.66
Cellflex 1/4"		5.5 / 1200	9.0 / 750	18.0 / 400	8.0	0.85
Cellflex 3/8"		3.8 / 2800	6.5 / 1200	13.0 / 680	15.0	0.85
Cellflex 1/2"		3.0 / 2800	5.6 / 1600	10.0 / 850	16.0	0.88
Cellflex 5/8"		2.5 / 4000	4.0 / 2300	7.2 / 1350	23.0	0.85

Velocity is the *Factor*?

Cable dielectric	Velocity factor (VF)
Solid polyethylene (PE)	0.659
Foam polyethylene	0.80
Air-space polyethylene	0.88
Foam polystyrene (PS)	0.91
Solid polytetrafluorethylene (PTFE)	0.695
Solid Teflon	0.69
Air-space Teflon	0.90

Velocity is the Factor!

- For highest accuracy, the velocity factor of any given cable is measured on a per-spool basis

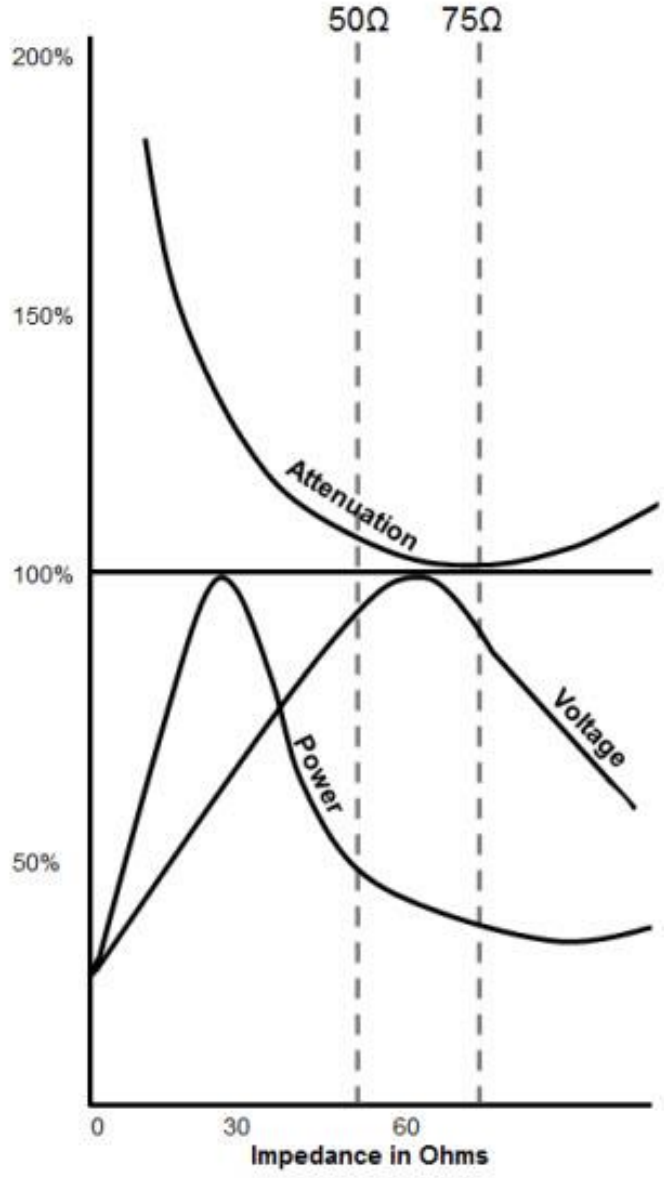
- This parameter is expected to not vary substantially on the cable in a given spool

- Cut a precisely measured physical length of cable, say 30 meters, and use a time domain reflectometer to measure the electrical length, then determine the Vp for the cable

Roll Your Own

- Cut and terminate your own cables
  - Velocity factor of preassembled cables is not guaranteed
  - Repeatable tests = all user port signals have identical and deterministic delays
  - Costs are lower (can be MUCH lower)
  - If a cable goes bad: just make a new one, quickly! No FEL. (FedEx Latency)
- *Labels* On Your *Cables*
  - More than just a catchy rhyme, it can save hours of tech time
  - One good alternative encountered: *make and use only standard lengths*
  - Always indicate electrical lengths of cables in lab test documentation

50 or 75?


50Ω
75Ω
200%
150%
100%
50%
Attenuation
Power
Voltage
0
30
60
Impedance in Ohms

50 or 75?

- 30 ohm cable has highest *power handling* per unit length
  - But it’s very hard to find! I am almost 54, and have never seen any.
- 75 ohm cable has the lowest *loss* per unit length
  - 52 ohms is simply a compromise value between these
- 75 ohm cable is usually less expensive than 50 ohm cable
- Also can be easier / cheaper to connectorize
- Timing labs generally don’t have high power requirements
- So …

Rooftop Alternatives

- What if you can't have a rooftop GPS antenna?
- Or, you ***can*** have one, but its performance is compromised?

- In the event of problems with GPS reception, a suitable lab multi-signal source may be put into Rubidium-backed holdover, providing:
  - T1, E1, 2.048 MHz, and 10 MHz inputs and outputs
  - 1 PPS and TOD output ports

Measurement Test Equipment

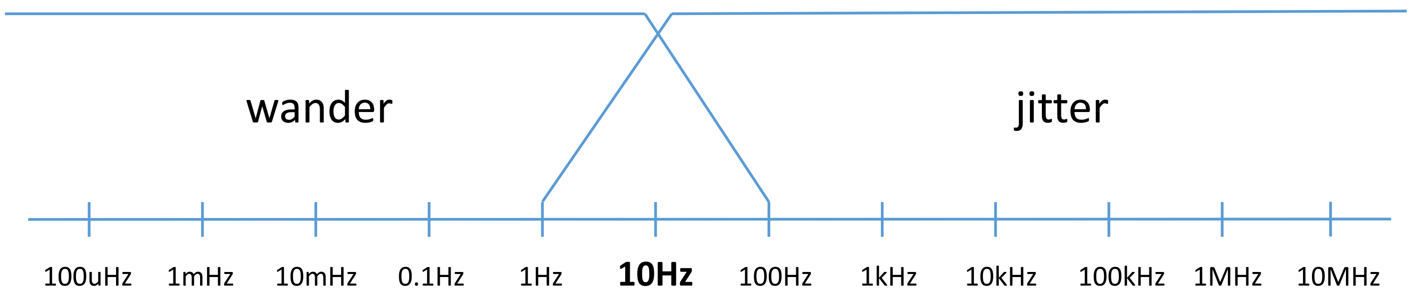
- Many vendors
- Differing packaging, benefits, features, and performance parameters
- Generally used to test conformance with ITU-T recommendations
- Also used for lab development (improvement in product performance, troubleshooting) and clock quality monitoring in live networks
- Convenient to consider capabilities in four test ‘arenas’
  1. Physical layer clock, so-called ‘synchronous Ethernet’
  2. Packet layer clock, IEEE 1588 Precision Time Protocol or PTP
  3. Testers that can measure both clocks simultaneously
  4. Other network clocks (circuit emulation, SAToP, etc.)

Jitter, Explained

… not to be confused with Packet Jitter or Packet Delay Variation (PDV)

- **Jitter** ('timing jitter' or 'physical layer jitter'): The short-term variations of the significant instants of a timing signal from their ideal positions in time (where short-term implies that these variations are of frequency greater than or equal to 10 Hz).

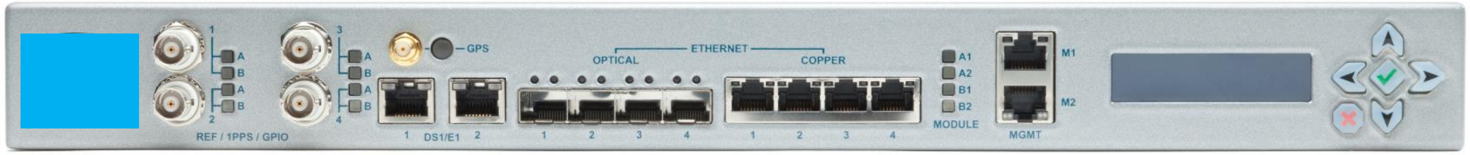
- **Wander**: The long-term variations of the significant instants of a digital signal from their ideal position in time (where long-term implies that these variations are of frequency less than 10 Hz).



"Significant instant" – is any convenient, easily identifiable point on the signal such as a rising or falling edge.

Ethernet PHY Clock

- Synchronous Ethernet
- Recovered clocks
- Frequency error / offset
- Time Interval Error
- Impairment generation (wander and / or jitter)
- ESMC



Ethernet Packet Clock

- Precision Time Protocol
- Packet Delay Variation
- Time Interval Error (and mathematical derivations)
- Phase Error
- Impairment options
- PTP Master and Slave options