Report of Time and Frequency Activities from INTI

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2017-10-26
Clocks and receivers
Organization of the Lab

Infrastructure

- 3 cesium clocks
- 3 GPS receivers
- 1 counter and 1 frequency generator for calibrations
- 1 phase comparison system (Multiplexer + counter)

Contribution to T&F networks

- SIM T&F, one clock
- UTC & UTCr, 3 clocks
- Red Nacional de Tiempo (RNT), 3 clocks
## Calibration and Measurement Capabilities

### Time and Frequency, Argentina, INTI (Instituto Nacional de Tecnologia Industrial)

<table>
<thead>
<tr>
<th>Calibration or Measurement Service</th>
<th>Measurand Level or Range</th>
<th>Measurement Conditions/Independent Variable</th>
<th>Expanded Uncertainty</th>
<th>Is the expanded uncertainty a relative one?</th>
<th>NMI Service Identifier</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Quantity</strong></td>
<td><strong>Instrument or Artifact</strong></td>
<td><strong>Instrument Type or Method</strong></td>
<td><strong>Minimum value</strong></td>
<td><strong>Maximum value</strong></td>
<td><strong>Units</strong></td>
<td><strong>Parameter</strong></td>
</tr>
<tr>
<td>Frequency</td>
<td>General frequency counter</td>
<td>Direct frequency measurement</td>
<td>5</td>
<td>5</td>
<td>MHz</td>
<td>Averaging time</td>
</tr>
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</tr>
<tr>
<td>Frequency</td>
<td>General frequency counter</td>
<td>Direct frequency measurement</td>
<td>10</td>
<td>10</td>
<td>MHz</td>
<td>Averaging time</td>
</tr>
<tr>
<td>Frequency</td>
<td>General frequency counter</td>
<td>Direct frequency measurement</td>
<td>10</td>
<td>10</td>
<td>MHz</td>
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</tr>
<tr>
<td>Frequency</td>
<td>General frequency counter</td>
<td>Direct frequency measurement</td>
<td>10</td>
<td>10</td>
<td>MHz</td>
<td>Averaging time</td>
</tr>
<tr>
<td>Frequency</td>
<td>General frequency source</td>
<td>Direct frequency measurement</td>
<td>1E-06</td>
<td>225</td>
<td>MHz</td>
<td>Averaging time</td>
</tr>
<tr>
<td>Time interval</td>
<td>Period source</td>
<td>Time interval counter</td>
<td>20</td>
<td>1E+09</td>
<td>ns</td>
<td>Slewing rate</td>
</tr>
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<td>Time interval</td>
<td>Time difference meter</td>
<td>Time interval counter</td>
<td>20</td>
<td>1E+09</td>
<td>ns</td>
<td>Slewing rate</td>
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</tbody>
</table>
Activities 2015-2017

- 12/15: 10-day visit to CENAM
- 9/17: Peer Review (Felicitas Arias)
- 9/17: Workshop of T&F Laboratories of Argentina in AGGO, with Felicitas
- 2 Publications
Activities 2015-2017. 2015: CV measurements

- **INTI**: Instituto Nacional de Tecnología Industrial. NMI of Argentina
- **ONBA**: Observatorio Naval de Buenos Aires. (Official time)
- **IGN**: Instituto Geográfico Nacional
- **AGGO**: Observatorio Argentino-Alemán de Geodesia (since en 2016)
Activities 2015-2017. 2015: CV measurements

Time Difference: INTI - IGN

No real time calculations. Data used with TCH technique
Stability: INTI-Cs1

Using TCH technique:

![Graph](image)

- Values OK with specs
- Consistent with UTCr
- $\tau^{-1}$: Flicker Phase Mod.
- $\tau^{-1/2}$: White Freq. Mod.
Next Step: "Real" time computation
Next Step: “Real” time computation
Next Step: “Real” time computation

Desvios de Allan entre relojes de la RNT durante el mes 4 de 2017

INTI1 - INTI2
INTI1 - ONBA
INTI1 - IGN
INTI1 - AGGO1
INTI1 - AGGO2

Desvios de Allan entre relojes de la RNT durante el mes 4 de 2017
According to specs, the accuracy of a std. cesium clock must be $\pm 50 \text{ ns/day}$.
Time Scales: Escala Argentina de Tiempo (EAT)

Specs

- Computations started in January 2017
- Uses 4 clocks: INTIx3 + AGGOx1
- CV comparisons + Kalman filter (for noise reduction)
- Weights as $\omega_i \propto \frac{1}{\sigma_i(\tau)}$, with $\tau = 10$ days
- Computed weekly, one point per day
- No physical output is generated
Time Scales: Escala Argentina de Tiempo (EAT)

\[ EAT(t) = \frac{\sum_{i=1}^{N} \omega_i [H_i(t) + A_i + D_i(t-t_0)]}{\sum_{i=1}^{N} \omega_i} \]

- \( H_i(t) \): reading of clock \( i \) at time \( t \)
- \( A_i \): time correction
- \( D_i \): last frequency value estimated over the previous interval of computation
- \( \omega_i \): weight of clock \( i \)
The scale started in January, but INTI-Cs3 was added in July
We still need to know how to deal with steps
Much more refinement is necessary
Time Scales: TA(INTI)

Specs

- Computations started in August 2017
- Uses the three clocks from INTI
- Time difference comparisons with SR620
  
  For the moment, $\omega_i \equiv 1/3$
- Computed daily with 10 points for each day.
Time Scales: TA(INTI)

- \( TA(INTI)(t) = \frac{\sum_{i=1}^{N} \omega_i [H_i(t) + A_i + D_i(t-t_0)]}{\sum_{i=1}^{N} \omega_i} \)

- \( H_i(t) \): reading of clock \( i \) at time \( t \)
- \( A_i \): time correction
- \( D_i \): last frequency value estimated over the previous interval of computation
- \( \omega_i \): weight of clock \( i \)
- We still need to know how to deal with steps
- Much more refinement is necessary
Despite of the steps, Allan deviations are OK, consistent with specs.
Whats next?

2017-2019

- More work on the two timescales
- Add clocks to the network "Red Nacional de Tiempo"
- 24 hour temperature + humidity + pressure monitor
- Build low cost GPS receivers (?)
That’s all

Thanks!