The Global Leader in Resilient PNT
Providing the world’s most critical applications real-time, accurate, reliable positioning, navigation, and timing data.

Safety, Security and Reliability

www.spectratime.com
www.t4science.com
www.spectracom.com
About Us
Founded in 2006 in Neuchatel, Switzerland, T4Science is a leading designer and manufacturer of a full range of advanced, cost-effective and high-performance MASER CLOCK solutions. Its products are used in a wide variety of scientific applications and in the time and frequency industry.
APPLICATIONS & ACCOUNT REFERENCES

Communications Network
- spectracom
- ADVA

SPACE
- ESA
- JAXA
- CNES
- OHB
- Thales Alenia Space

Navigation
- Galileo
- GAGAN
- BeiDou
- NAVIC
- CETC

Science
- MIT
- NRAO
- SKA
- ESO
- Max-Planck-Institut für Radioastronomie

National Timing Laboratories
- NMIJ
- METAS
- INAF
- NPL
- NMISA

DEFENSE / Security
- DGA
- HARRIS
APPLICATIONS & ACCOUNT REFERENCES

Communications Network
> Smart rubidium clocks for telecom and wireless networks

Defense
> Rugged MIL rubidium clocks for avionics & comms systems

Navigation
> High precision GPS clocks for positioning & location

Broadcasting
> GPS clock references for IP/DVD/HDTV systems

Instrument
> Low noise clock sources for precise tests & measurements

Space
Master clocks for GPS/GNSS satellite navigation systems
<table>
<thead>
<tr>
<th>PRODUCTS OVERVIEW (Q2 2019):</th>
<th>COMPONENTS</th>
<th>SYSTEMS</th>
</tr>
</thead>
</table>
| **iSource+®** | Rb Oscillators | **iReference+®**
| **iSpace+™** | Low SWaP Oscillators | GPS/GNSS Rb OCXO Standards |
| **iSync+®** | GPS/GNSS Rb OCXO Oscillators | GPS/Rb locked Rb |
| | GPS/Rb or OCXO | GPS/Rb & LN OCXO |
| | GPS-locked Rb & LN OCXO | A/P Masers |
| **iTest+®** | Clock Instruments | 1ps ADEV |

**COMPONENTS:**
- New Rb Oscillators
- New Low SWaP Oscillators
- New MiniRb
- New PMs
- New GPS/GNSS Rb OCXO Oscillators
- New GPS-locked Rb & LN OCXO
- New GPS/Rb or OCXO
- New GPS/Rb locked Rb
- New GPS/Rb & LN OCXO
- New A/P Masers

**SYSTEMS:**
- 1ps ADEV
- GPS Rb & 1ps ADEV
- 100fs Synthesizer
HYDROGEN MASER PRINCIPLE

MASER
Microwave Amplification by Stimulated Emission of Radiation
Oscillator based on quantum transitions of Hydrogen atoms

HIGH ATOMIC QUALITY FACTOR
>1E+9 (1Hz / 1.4GHz) for Hydrogen

CAVITY FACTOR
Qcav > 30000 Active
Qcav < 30000 Passive
APPLICATION

VLBI / Earth Observation

– Event Horizon Telescope Results

• First image of a black hole.
APPLICATION

– Deep Space Tracking

– Timing / Metrology Station
  • National Time
    – METAS(CH)
    – INRIM (I)
    – TL (TW)
    – NMI(SA)
    – NPL (UK)
    – …
Navigation Programs (Ground Station)

- Galileo, India, China, Japan ...

Electronic

- SLR / Radar
ON BOARD CLOCKS AND GNSS PROGRAMS

- Rubidium
- Cesium
- Hydrogen Maser
- Rubidium
- Rubidium (1)
- Rubidium (2)

IRNSS

Navstar GPS
GLONASS
GALILEO
IS-GOSS
Indian Regional Navigation Satellite System (IRNSS)

SHM (Space Hydrogen Maser) for Space Science

ACES mission on the International Space Station
- Launch: ~2020
- Demonstrate the high performances of a new generation of space clocks
- Perform fundamental physics tests (Einstein’s general relativity and theories of gravitation)

Cooperation in space science
- Fundamental physics:
  - \textit{E-GRIP} - Einstein Gravitational Red-Shift Probe
  - Chinese Space Station?
- Astrophysics: \textit{Space VLBI}?
A LARGE PORTFOLIO FOR HIGH DEMANDING APPLICATIONS

Time & Frequency Reference System
High performance Synchronization Solutions
High reliable T&F Distribution
Network Time Servers
GNSS Master Clock
PTP Grandmaster
UTC traceability and real-time reporting software
Resilient PNT Solutions

Defense, Air, Land and Maritime
Critical Infrastructure Systems
Enterprise Network Timing
Big Data
Automotive Navigation
Financial Services
Unmanned Systems
T4SCIENCE CUSTOMER & LOCATION

39 years operations
More than 130 masers operating!
Worldwide customers on all continents
Solution for all environments (including installation and services)
• 5000 m altitude
• Isolated Island
• South/ North poles
• 2 MASER Units successfully installed in Meerkat
TYPICAL PERFORMANCE AHM +HCB+ FEMTO STEPPER

New Short term at 6E-14 @ 1s available!!!
NEW PERFORMANCE AHM

New Phase noise at 5MHz 1 Hz: -133 and floor at -162 dBc
MAINTENANCE / SERVICE

LIFETIME > 20 YEARS
EFOS 1 still operating in WETTZELL for 39 years
MTBF > 20 YEARS
>600 years of cumulative operation
FAST MAINTENANCE
SUPPORT AVAILABLE WORLD WIDE
INPUT SIGNALS – SINUSOIDAL 100 MHZ, (0.4 – 0.8) VRMS AND PULSES 1PPS, (2 – 5) VAMP. INPUT IMPEDANCE – 50 OHMS.

OUTPUT SIGNALS – SINUSOIDAL 5, 10, 100 MHZ, (0.4 – 0.8) VRMS AND PULSES 1PPS, (2 – 5) VA AT 50 OHMS LOAD.

ADDED BY THE MODEM FREQUENCY INSTABILITY (ALLAN VARIANCE, MEASURED IN PASSBAND 3HZ) NOT MORE THAN

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Allan variance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6×10⁻¹⁴</td>
</tr>
<tr>
<td>10</td>
<td>8×10⁻¹⁵</td>
</tr>
<tr>
<td>100</td>
<td>1×10⁻¹⁵</td>
</tr>
<tr>
<td>1000</td>
<td>5×10⁻¹⁶</td>
</tr>
<tr>
<td>10000</td>
<td>2×10⁻¹⁶</td>
</tr>
</tbody>
</table>

Output (remote) 1PPS to input (local) 1PPS synchronization error – not more than 250 ps.

Fiber length – up to 100 km (w/o optical amplifier).

Optical connectors – FC/APC.

RF connectors – SMA.

Optical wavelength – 1310 nm (1PPS modulated), 1550 nm (100 MHz modulated).

Output optical power – not less than 4 mW.

Size – 1U case (483×44×310 mm), can be mounted in 19” rack.

Power – 220 V, 50 Hz AC.

Power consumption – 30 V·A.

Operating temperature range – (+5 ÷ +40) °C.

Weight – not more than 3 kg.
TYPICAL PERFORMANCE AHM VIA OPTICAL FIBER MODEM

![FREQUENCY STABILITY](FREQUENCY_STABILITY.png)
THANK YOU FOR YOUR ATTENTION