

**Optically-Pumped Cesium Clock**  
from  
**Chengdu Spaceon Electronics Co. Ltd.**



# Cesium Clock Spaceon



- ✘ **Optically-pumped Cesium Clock – Product realization in 2016 and commercially available since 2018. The development was started 2009 with support of the Chinese National Key Scientific Instrument and Equipment Development Project.**
- ✘ **The clock has proven performance and was supplied to several customers. Performance was measured by National Institute of Metrology (NIM) and China and National Time Service Center (NTSC), China.**
- ✘ **The clock has won the “Golden Award of Innovation” at the 20<sup>th</sup> China International Industry Fair 2018. Cesium clocks from Spaceon contribute to the BIPM Time Data Base.**
- ✘ **Available models:  
AXCS9000(STD) “Standard Performance and AXCS9000HP “High Performance”**

# Cesium Clock Spaceon



- ✘ Several sets (Standard & High Performance Model) were tested by NIM & NTSC China



- ✘ 8 evaluation runs by institutes and customers from different industries (more in progress)
- ✘ More than 30 different environmental test were performed (including vibration)
- ✘ More than 40 sets are continuously operating for evaluation of long-term stability



# Cesium Clock Spaceon



中国计量科学研究院  
National Institute of Metrology, China

**测试报告**  
Test Report

报告编号 SPSS2019-0404  
Report No.

客户名称 成都天奥电子股份有限公司  
Client Chengdu Spaceon Electronics Co., Ltd

样品名称 激光抽运小型铯原子钟  
Sample OPTICAL CESIUM FREQUENCY STANDARD

型号/规格 TA1000  
Type/Model

出厂编号 1702002  
Serial No.

生产厂商 成都天奥电子股份有限公司  
Manufacturer Chengdu Spaceon Electronics Co., Ltd

客户地址 中国成都市金牛区金科东路50号国宾馆总部基地2号楼  
Client Address 2# building of 50 Jinke Road East, Jinke District, Chengdu City, China

测试日期 2019年3月21日  
Date of Test 2019/3/21

批准人: 梁坤  
Approved by



地址: 中国 北京 北三环东路 18 号  
Address: No.18 Bei San Huan Dong Lu, Beijing, P.R.China 邮编: 100029  
Post Code  
电话: +86-10-64525569/74  
Tel 传真: +86-10-64271948  
Fax  
网址: <http://www.nim.ac.cn>  
Website 电子邮箱: kehuifuwu@nim.ac.cn  
Email

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Certificate of NIM

中国科学院国家授时中心认证检测实验室  
Accreditation & Testing Laboratory of National Time Service Center, CAS

**检测报告**  
TEST REPORT

中国认可  
检测  
TESTING  
CNAS L11069

报告编号: NTSCTL-TF-2019-0049  
Test Report No.

送检单位: 成都天奥电子股份有限公司  
Customer: Chengdu Spaceon Electronics Co., Ltd

地址: 成都市金牛区金科东路 50 号国宾馆总部基地 2 号楼  
Address: Building 2, State Guest Headquarters Base, No.50, Jinke East Road, Jinniu District, Chengdu


设备名称: TA1000 激光抽运小型铯原子钟  
Equipment: Optically-pumped Cesium Atomic Clock TA1000

型号规格: TA1000  
Model Type

出厂编号: 1702031  
Serial No.

制造商: 成都天奥电子股份有限公司  
Manufacturer: Chengdu Spaceon Electronics Co., Ltd

批准人 梁坤  
Authorized by

检测单位: (检测专用章)  
Issued by (Stamp) 

审核人 梁坤  
Verified by

检测人 屈例例  
Operator by

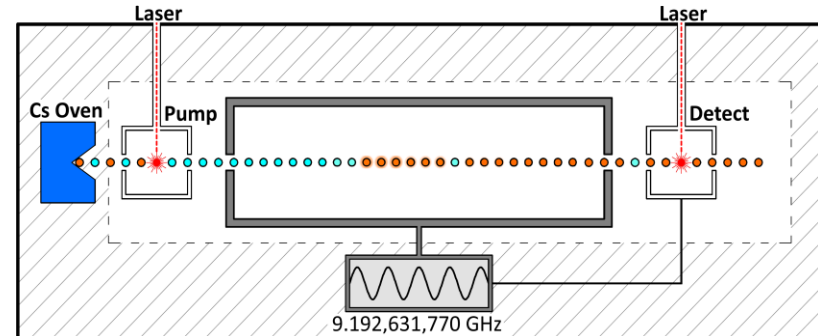
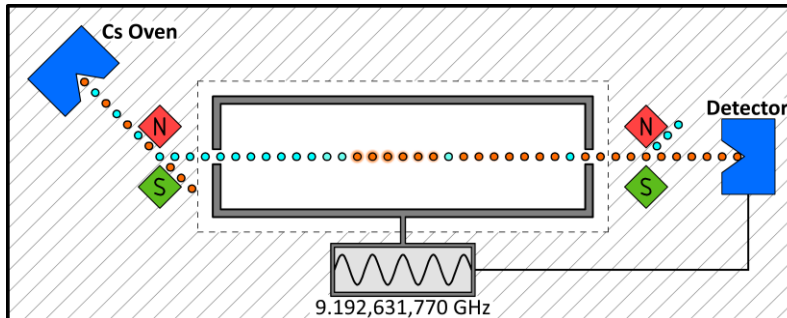
报告日期: 2019 年 09 月 16 日  
Issued Date Year Month Day

地址 (Add): 西安市临潼区书院东路 3 号  
电话 (Tel): (029) 838900380  
传真 (Fax): (029) 83890326  
邮编 (Post Code): 710600

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Certificate of NTSC

# Comparison - Technology



## Magnetic deflection

Very weak flux of atoms  
 Magnetic deflection → Selection of atoms  
 Selection by velocity with bended beam  
 Only about 1% of atoms can be used

Beam adjustment critical (bended beam)  
 Cesium tube has complex optical beam  
 and is difficult to manufacture

Detector needs electron multiplier, which has  
 limited life time due to surface ionization

Critical components (electron multiplier, magnetic  
 units) are within the vacuum chamber

## Optical pumping

100 times higher flux of atoms  
 100% of atoms are used due to optical pumping (Laser)  
 No selection by velocity → straight beam

Simple beam adjustment (straight beam)  
 Simple Cesium tube structure (no optical problem)  
 High reliability

Optical detection (Laser & photo detector)  
 leads to high efficiency and avoids electron multiplier

Critical components (laser, photo detector) are outside  
 of the vacuum chamber

# Comparison - Technology



| Magnetic deflection  | Optical pumping  |
|--|--|
| Technology is affected by several factors, such as Majorana transition, Doppler effect, Zeeman effect etc. (mainly due to the used magnetic field)   | Technology is much less affected by physical factors Cesium tube design and entire manufacturing process are greatly simplified  |
| Technology results in low SNR and poor short-term stability  | SNR is significantly improved<br>High frequency stability  |
| Accuracy <math><1E-12</math><br>Typical ADEV = <math&gt;2.7e-11 math="" sqrt(\text{tau})&lt;=""><br/>STS: <math&gt;1.2e-11&lt; 1="" @="" math&gt;="" sec<br=""></math&gt;1.2e-11&lt;>LTS: <math&gt;5e-14&lt; 1="" @="" day<="" math&gt;="" td=""> <td>Accuracy &lt;math&gt;&lt;5E-13&lt;/math&gt;<br/>Typical ADEV = <math&gt;2.7e-12 math="" sqrt(\text{tau})&lt;=""><br/>STS: <math&gt;3e-12&lt; 1="" @="" math&gt;="" sec<br=""></math&gt;3e-12&lt;>LTS: <math&gt;1e-14&lt; 1="" @="" day<="" math&gt;="" td=""> </math&gt;1e-14&lt;></math&gt;2.7e-12></td></math&gt;5e-14&lt;></math&gt;2.7e-11> | Accuracy <math><5E-13</math><br>Typical ADEV = <math&gt;2.7e-12 math="" sqrt(\text{tau})&lt;=""><br/>STS: <math&gt;3e-12&lt; 1="" @="" math&gt;="" sec<br=""></math&gt;3e-12&lt;>LTS: <math&gt;1e-14&lt; 1="" @="" day<="" math&gt;="" td=""> </math&gt;1e-14&lt;></math&gt;2.7e-12> |

## Commercially available Cesium Clocks

| Microsemi 5071A     | Oscilloquartz (ADVA) 3235B | Spaceon AXCS9000 |
|---------------------|----------------------------|------------------|
| Magnetic deflection | Magnetic deflection        | Optical pumping  |

# Performance – Stability (ADEV)



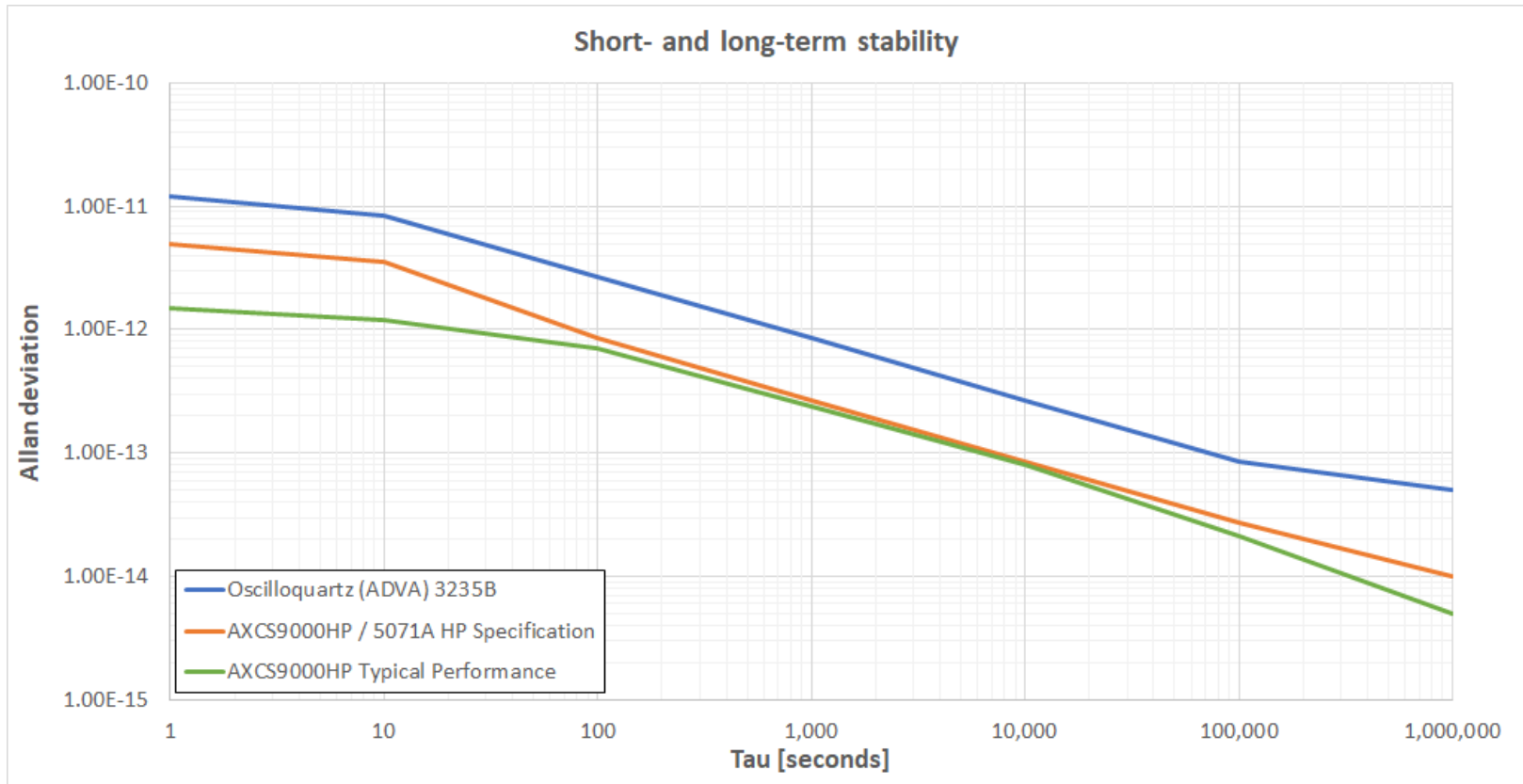
| tau         | ADVA 3235B<br>(max.) | AXCS9000HP / 5071A HP<br>(max.) | AXCS9000HP<br>(best) |
|-------------|----------------------|---------------------------------|----------------------|
| 1 sec       | 1.2E-11              | 5.0E-12                         | 1.5E-12              |
| 10 sec      | 8.5E-12              | 3.5E-12                         | 1.2E-12              |
| 100 sec     | 2.7E-12              | 8.5E-13                         | 7.0E-13              |
| 1,000 sec   | 8.5E-13              | 2.7E-13                         | 2.4E-13              |
| 10,000 sec  | 2.7E-13              | 8.5E-14                         | 8.1E-14              |
| 100,000 sec | 8.5E-14              | 2.7E-14                         | 2.1E-14              |
| Floor       | 5.0E-14              | 1.0E-14                         | 5.0E-15              |

✗ Performance of standard and high performance model was measured and verified by National Institute of Metrology (NIM) (report & certificate available).



✗ Maximum short- and long term specification is identical with Microsemi 5071A High Performance specification. But NIM measurements showed, that the long-term stability of AXCS9000HP is better than the 5071A HP (which uses magnetic deflection instead of optical pumping)





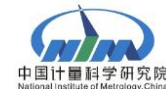


# Performance – Phase noise

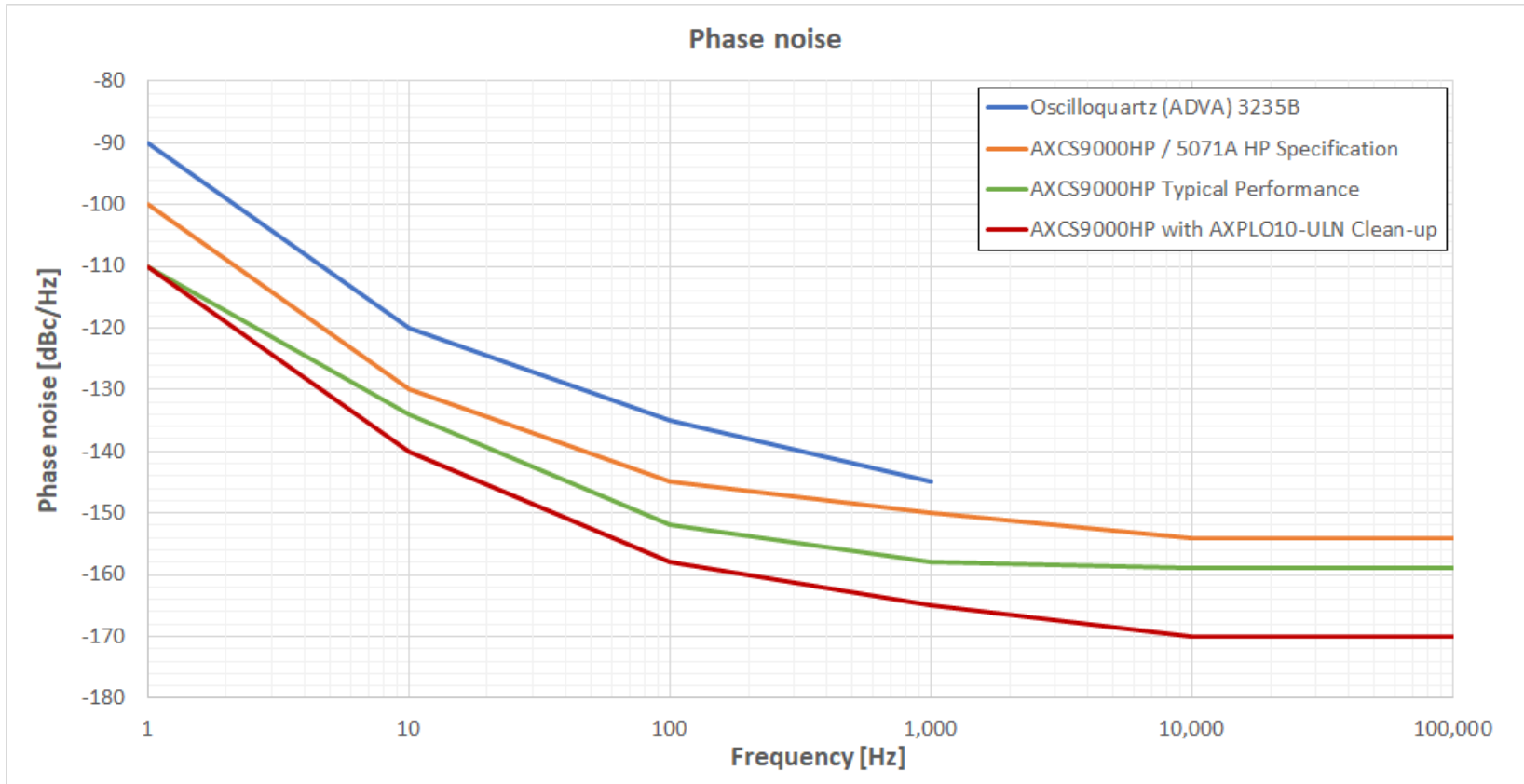


| Frequency | ADVA 3235B<br>(max.) | AXCS9000HP / 5071A HP<br>(max.) | AXCS9000HP<br>(typ.) |
|-----------|----------------------|---------------------------------|----------------------|
| 1 Hz      | -90 dBc/Hz           | -100 dBc/Hz                     | -110 dBc/Hz          |
| 10 Hz     | -120 dBc/Hz          | -130 dBc/Hz                     | -134 dBc/Hz          |
| 100 Hz    | -135 dBc/Hz          | -145 dBc/Hz                     | -152 dBc/Hz          |
| 1 kHz     | -145 dBc/Hz          | -150 dBc/Hz                     | -158 dBc/Hz          |
| 10 kHz    | not specified        | -154 dBc/Hz                     | -159 dBc/Hz          |
| 100 kHz   | not specified        | -154 dBc/Hz                     | -159 dBc/Hz          |

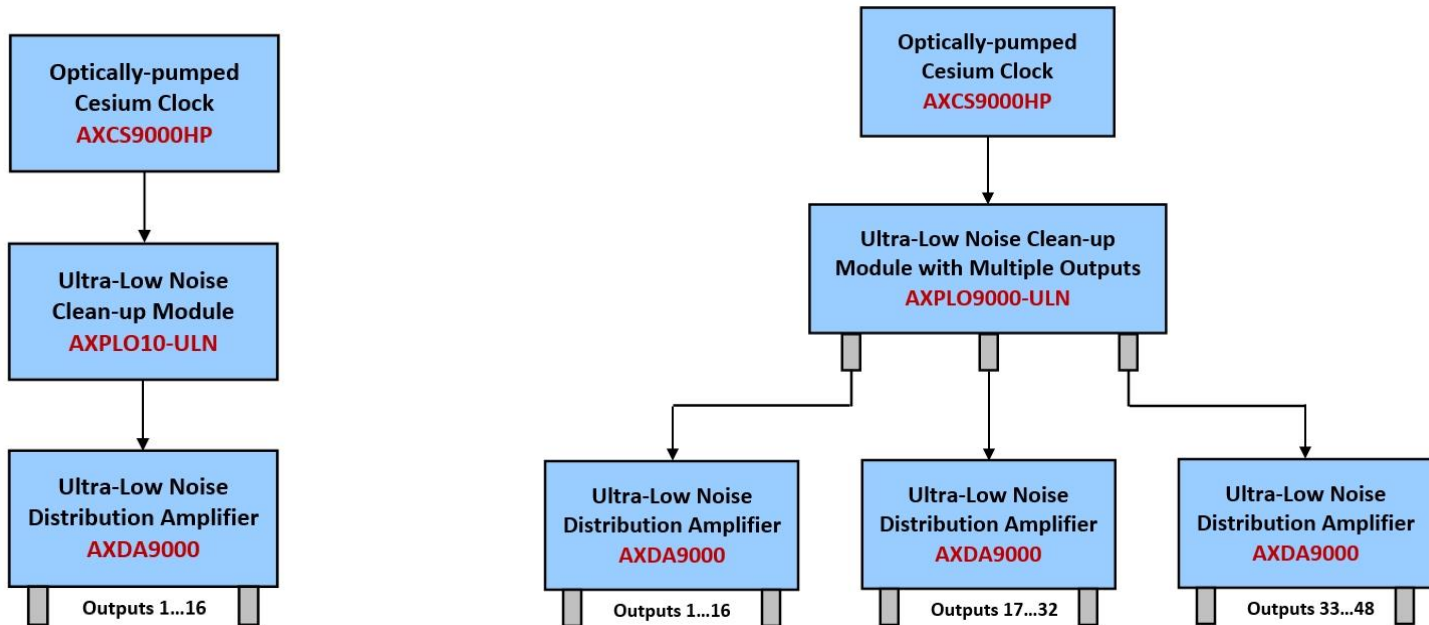
- ✘ Performance of standard and high performance model was measured and verified by National Institute of Metrology (NIM) (report & certificate available).
- ✘ Maximum phase noise specification is identical with Microsemi 5071A High Performance specification.
- ✘ For improved phase noise performance: AXTAL clean-up module **AXPLO10-ULN** is available, which can be combined with AXCS9000. It improves phase noise  $\geq 1$  Hz (ADEV < 1 sec), while the short-term stability for  $\tau > 1$  sec is determined by the Cesium clock.



# Performance – Phase noise



# ULN Frequency Distribution (Optional)



**Basic configuration with up to 16 outputs for 10 MHz distribution**

**Cascadable 10 MHz frequency distribution configuration with up to 48 outputs**  
 - All modules in 19 inch rack -  
 - 1 PPS distribution modules available -



# Life Time, Guaranty & Maintenance/Repair/Support



- ✘ **Guaranteed life time (Cesium Tube) is min. 8 years for High Performance Model AXCS9000HP.**
- ✘ **About 40 pieces were manufactured and delivered to different customers and institutes. Several evaluation measurements are currently performed by new key customers.**
- ✘ **Standard guaranty is 1 year (repair free of charge). Extended guaranty of 5 years available at additional charge.**
- ✘ **Maintenance, Repair & Support:**
  - ✘ **If any issue or failure is reported by the customer, response by Spaceon/AXTAL within 2~3 days at the latest.**
  - ✘ **For minor issues and problems, that cannot be solved by email or phone, customer visit by AXTAL service personnel within 2~3 days is possible (Europe).**
  - ✘ **For critical failures or Cesium tube replacement, the customer will receive a spare clock either directly from AXTAL, or by air cargo within one week (depending on urgency and availability) until the failure clock is repaired.**
  - ✘ **General technical support is done by AXTAL (email, phone & customer visit).**



# Spaceon / AXTAL



## THANK YOU!

Visit us at  
**[www.axtal.com](http://www.axtal.com)**

**AXTAL is official representative of Spaceon in Europe**