

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), China and National Time Service Center (NTSC), China.**
- ✘ **The clock has won the “Golden Award of Innovation” at the 20th China International Industry Fair 2018. Cesium clocks from Spaceon contribute to the BIPM Time Data Base.**
- ✘ **Available models:
AXCS9000STD “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 tests were performed (including vibration)
- ✘ More than 60 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 Guo Jia Headquarter Base, No.50 Jin Ke Road East, Jin Niu 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
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2
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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 CNAS 中国认可
TESTING TESTING
CNAS L11069

TEST REPORT

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 Authorized by: [Signature]

检测单位: (检测专用章)
Issued by (Stamp) 检测专用章

审核人 Verified by: [Signature]

检测人 Operator by: [Signature]

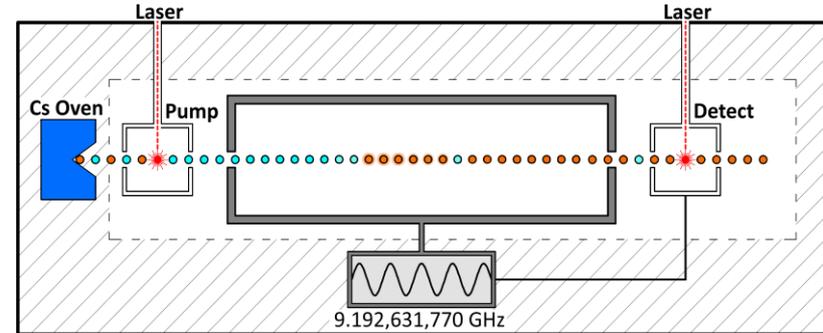
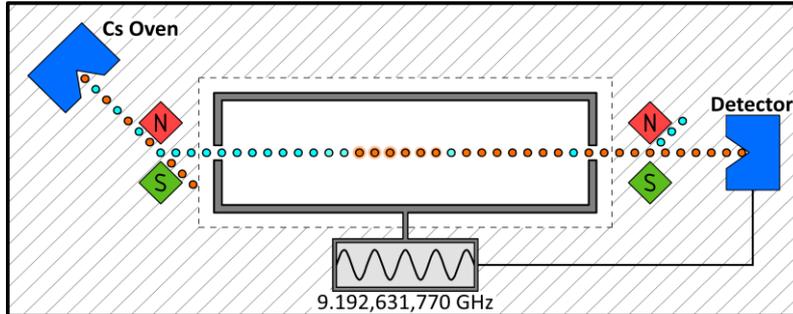
报告日期: 2019年 09月 16日
Issued Date Year Month Day

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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 High frequency stability
Accuracy <math><1E-12</math> Typical ADEV = <math>2.7e-11 math="" sqrt(\text{tau})<=""> STS: <math>1.2e-11< 1="" @="" math>="" sec<br=""></math>1.2e-11<>LTS: <math>5e-14< 1="" @="" day<="" math>="" td=""> <td>Accuracy <math><5E-13</math> Typical ADEV = <math>2.7e-12 math="" sqrt(\text{tau})<=""> STS: <math>3e-12< 1="" @="" math>="" sec<br=""></math>3e-12<>LTS: <math>1e-14< 1="" @="" day<="" math>="" td=""> </math>1e-14<></math>2.7e-12></td></math>5e-14<></math>2.7e-11>	Accuracy <math><5E-13</math> Typical ADEV = <math>2.7e-12 math="" sqrt(\text{tau})<=""> STS: <math>3e-12< 1="" @="" math>="" sec<br=""></math>3e-12<>LTS: <math>1e-14< 1="" @="" day<="" math>="" td=""> </math>1e-14<></math>2.7e-12>

Commercially available Cesium Clocks

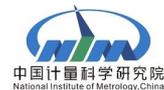
Microsemi 5071A	Oscilloquartz (ADVA) 3235B	Spaceon AXCS9000
Magnetic deflection	Magnetic deflection	Optical pumping

Performance – Stability (ADEV)

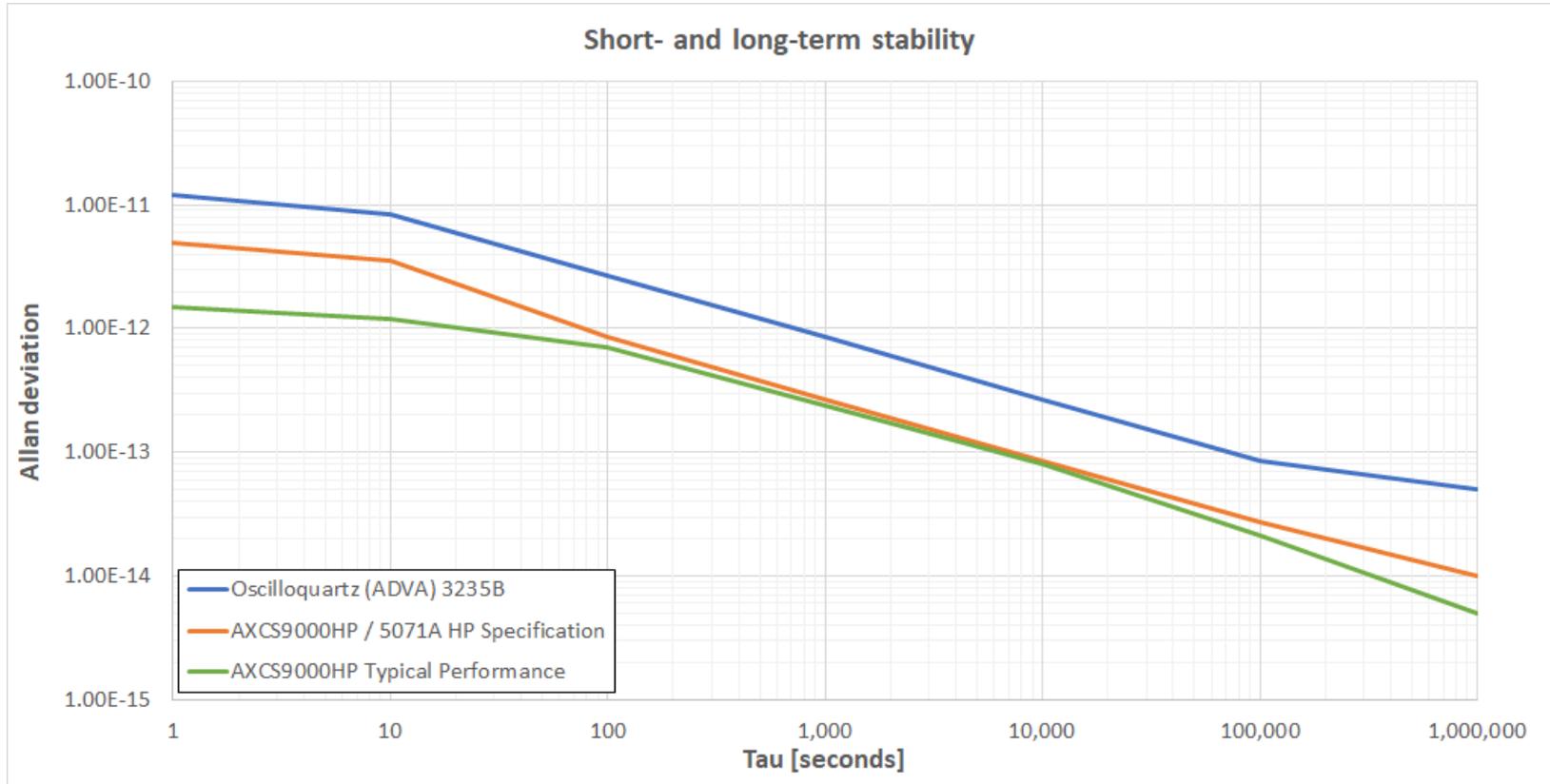


tau	ADVA 3235B (max.)	AXCS9000HP / 5071A HP (max.)	AXCS9000HP (best)
1 sec	1.2E-11	5.0E-12	1.5E-12
10 sec	8.5E-12	3.5E-12	1.2E-12
100 sec	2.7E-12	8.5E-13	7.0E-13
1,000 sec	8.5E-13	2.7E-13	2.4E-13
10,000 sec	2.7E-13	8.5E-14	8.1E-14
100,000 sec	8.5E-14	2.7E-14	2.1E-14
Floor	5.0E-14	1.0E-14	5.0E-15

✘ 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

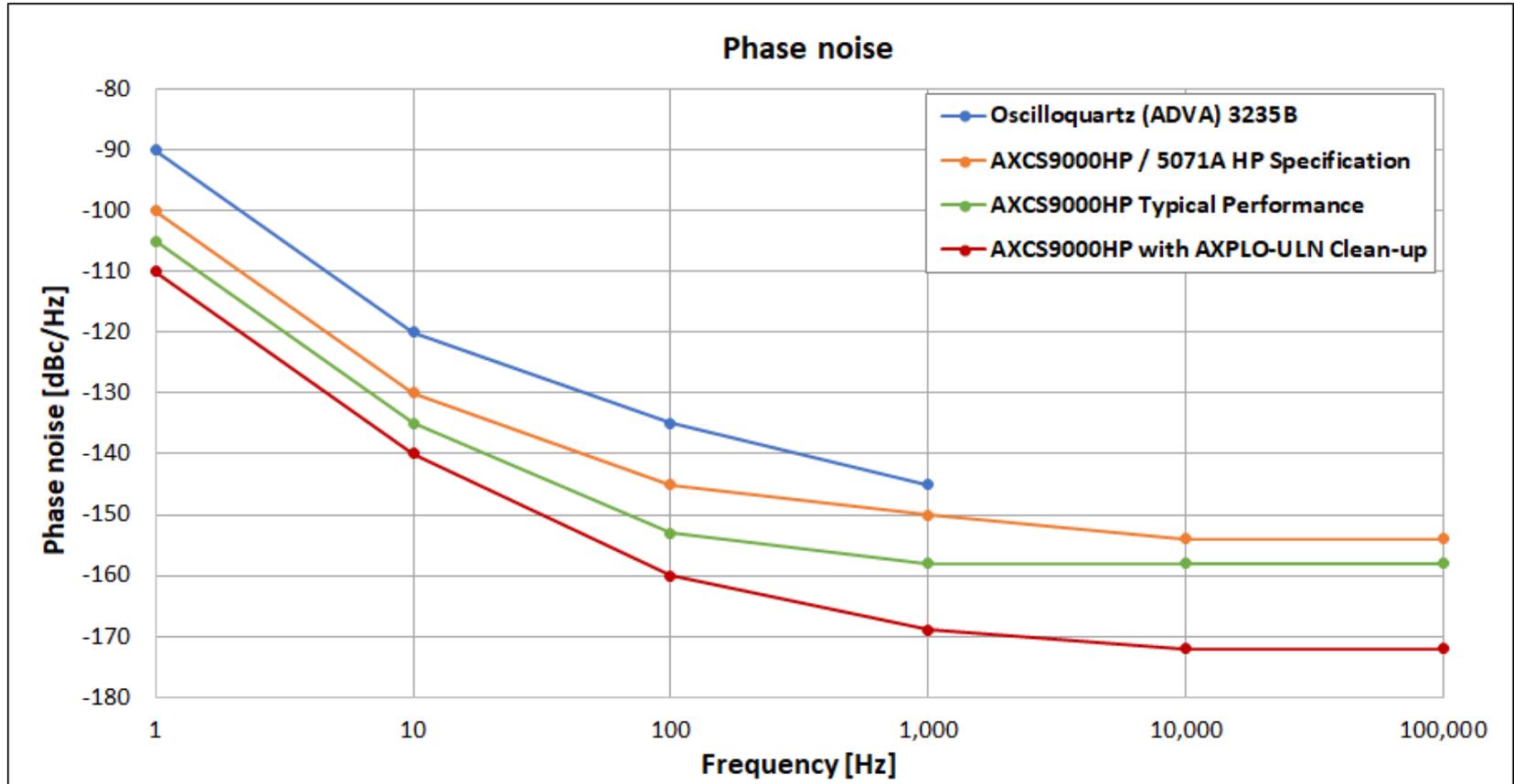


Frequency	ADVA 3235B (max.)	AXCS9000HP / 5071A HP (max.)	AXCS9000HP (typ.)
1 Hz	-90 dBc/Hz	-100 dBc/Hz	-105 dBc/Hz
10 Hz	-120 dBc/Hz	-130 dBc/Hz	-135 dBc/Hz
100 Hz	-135 dBc/Hz	-145 dBc/Hz	-153 dBc/Hz
1 kHz	-145 dBc/Hz	-150 dBc/Hz	-158 dBc/Hz
10 kHz	not specified	-154 dBc/Hz	-158 dBc/Hz
100 kHz	not specified	-154 dBc/Hz	-158 dBc/Hz

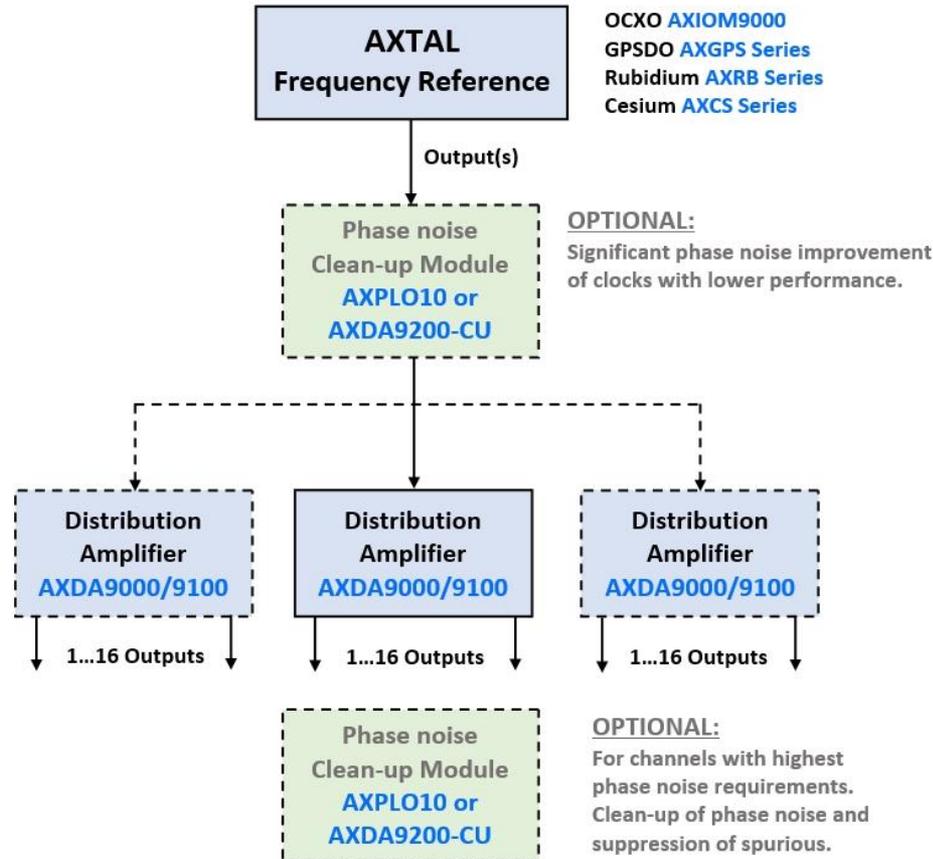
- ✘ Performance of standard and high performance model was measured and verified by National Institute of Metrology (NIM) (report & certificate available).
- ✘ Maximum phase noise specification is identical with Microsemi 5071A High Performance specification.
- ✘ For improved phase noise performance: AXTAL clean-up modules **AXPLO10-ULN & AXPLO9000CU** are available, which can be combined with AXCS9000. It improves phase noise ≥ 1 Hz (ADEV < 1 s), while the short-term stability for $\tau > 1$ sec is determined by the Cesium clock.



Performance – Phase noise



ULN Frequency Distribution 1PPS & 5/10 MHz (Optional)





Life Time, Guaranty & Maintenance/Repair/Support



- ✘ **Guaranteed life time (Cesium Tube) is min. 10 years for High Performance Model AXCS9000HP.**
- ✘ **About 60 pieces were manufactured and delivered to different customers and institutes. Several evaluation measurements are currently performed by new key customers.**
- ✘ **Standard guaranty is 2 years (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

AXTAL is official representative of Spaceon in Europe