Comparing Miniature Atomic Clocks

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T&F Experts

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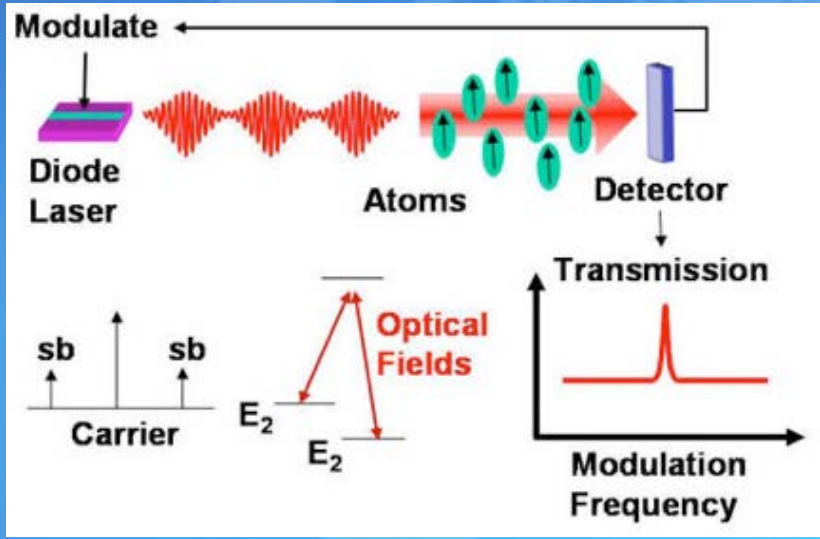
CPT Clock

Working principle



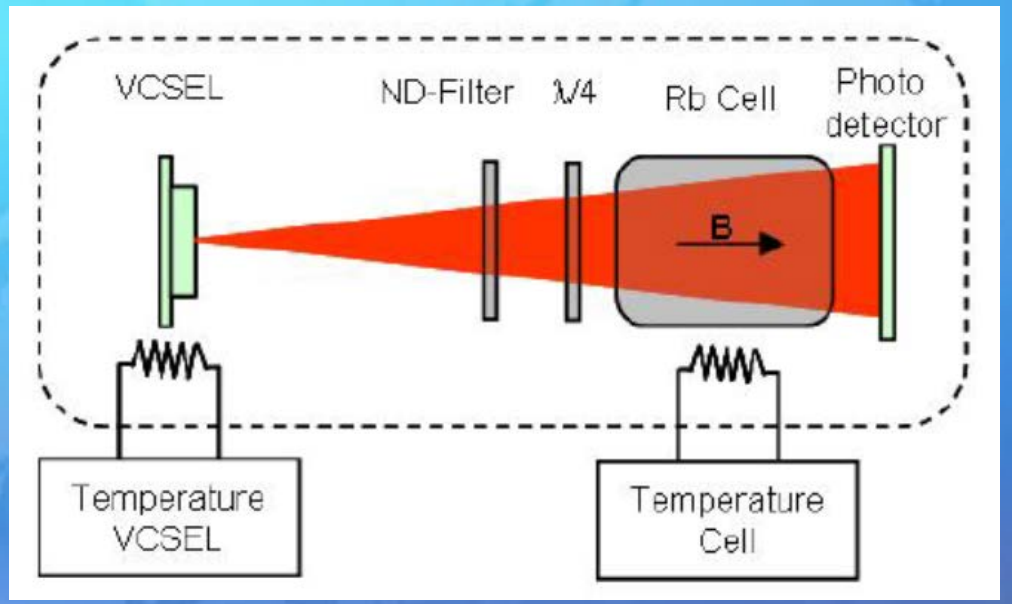
© https://tf.nist.gov/ofm/smallclock/CPT_clocks.html

➢Theory: Coherent PopulationTrap(CPT) — No absorption while two energy levels are confined by two lasers; then dark line can act as the clock reference while tuning the CPT

Advantages

① No cavity & laser source: size and power consumption will be reduced without limitation with MEMS&CMOS fabrication procession

② Chip-scale size and power



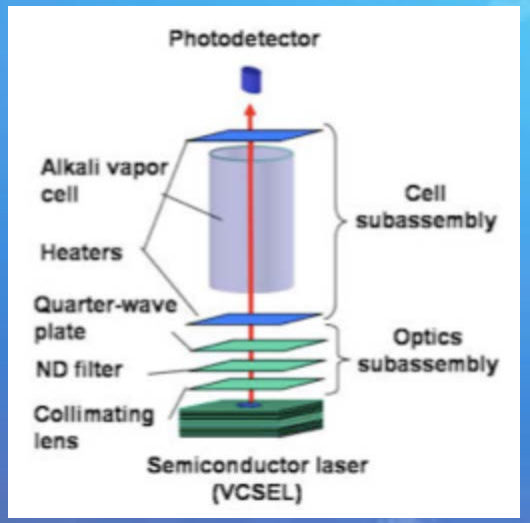
CPT Clock: prototype

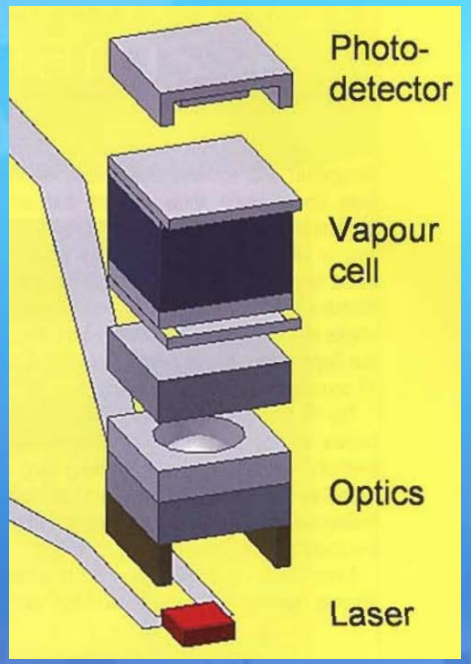
Chip SIze Atomic Clock

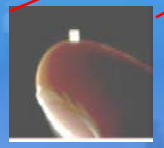
① CPT theory found by Vanier(Canadian scientist)

② The first prototype was made by NIST USA with MEMS

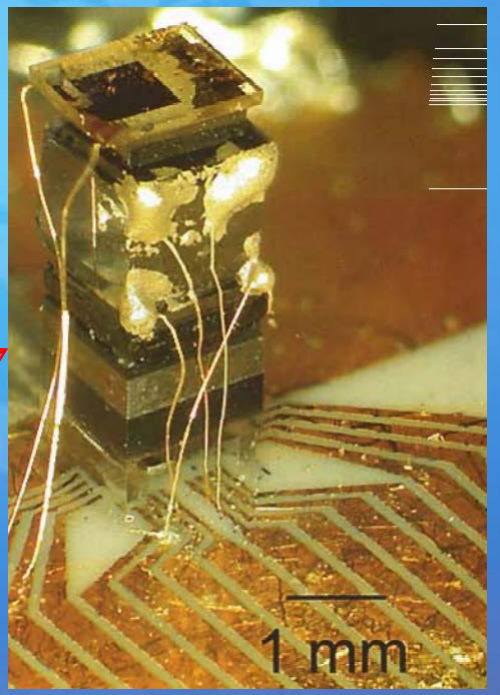
③ No formal commercial product







MEMS atomic bulb



Vacuum Physical System

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CPT Clock product: SA.3x (MAC)

Key Features

① High precision atomic clock
② Smallest form factor
③ Oscillator pinouts
④ Low power consumption
⑤ RoHs 6/6 compliant

Key Specifications

① Output frequency: 10MHz
② Phase noise: SA.35m/SA.33m SA.31m

1 Hz	<-70 dBc/Hz	<-65 dBc/Hz
10 Hz	<-87 dBc/Hz	<-85 dBc/Hz
100 Hz	<-114 dBc/Hz	<-112 dBc/Hz
1 kHz	<-130 dBc/Hz	<-130 dBc/Hz
10 kHz	<-140 dBc/Hz	<-140 dBc/Hz

③ Short-term stability: ≦5E-11/ ≦3E-11/
④ Aging: ＜±2.5E-11/day ＜±5E-11/day
⑤Repeatability: ≦ 5E-11
⑥ Operating temperature: -10℃~ 75℃
⑦ Size: 51*51*18(mm^3)

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CPT Clock product: SA.45 (CSAC)

Key Features

① Power consumption < 120mW
② Less than 17cm³ volume
③ 10 MHz CMOS compatible output
④ 1PPS in /out for synchronization
⑤ RS-232 for monitoring

Key Specifications

① Output frequency: 10MHz
② Short term stability: ≦2.5E-10/
③ Phase noise(SSB):

1 Hz <-50 dBc/Hz
10 Hz <-70 dBc/Hz
100 Hz <-113 dBc/Hz
1 kHz <-128 dBc/Hz
10 kHz <-140 dBc/Hz

④ Aging: ＜±9E-10/ month
⑤Repeatability: ≦ 5E-10
⑥ Operating temperature: -10℃~ 35℃
⑦ Size: 1.6''*1.39''*0.45“ (40.6×35.3×11.4 mm³)

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Our CPT Clock XHTF1040 (AXCPT1040)

Key Features

① Miniaturization
② 3.3V low voltage supply,
1.5W low power consumption
③ UART serial port communication
④ Reference second synchronization
& 1 PPS output
⑤ TOD output

Key Specifications

① Output frequency: 10MHz
② Short term stability: ≦2E-10/
③ Phase noise(SSB): ≦-90dBc/Hz @10Hz
≦-120dBc/Hz @10Hz
≦-140dBc/Hz @10Hz
≦-145dBc/Hz @10Hz
④ Frequency deviation: ＜3E-11/per day
⑤ Starting-up feature(Norm.temp): ≦5min lock
⑥ Repeatability: ≦ 5E-11
⑦ Reference second synchronization:
1 PPS synchronization accuracy ≤±50ns
⑧ Operating temperature: -45℃~ 65℃
⑨ Size: 45 *36*15 mm^3

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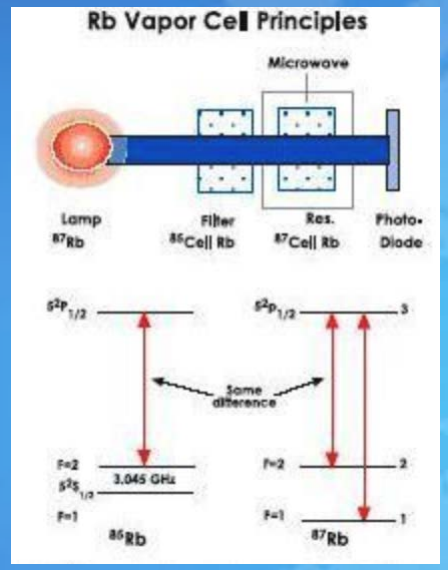
Comparison of CPT clocks

	vacuum sealing	size（mm）	power(w)（@25℃）	cost/price	reliability
SA.3x	NO	51×51×18	5	medium	high
SA.45	YES	40.6×35.3×11.4	0.115	very high	medium
XHTF1040 (AXCPT1040)	NO	45×36×14.5	2.5	medium	high

Conventional Rb Clocks

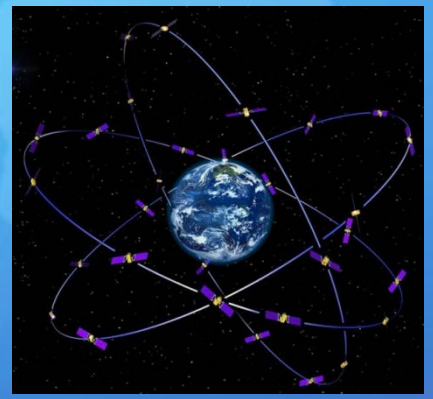
Working principle



➢Theory: Rubidium lamp pumps Rubidium atoms into absorbing cell to invert population: The clock transition will occur at 6.8GHz. RF stimulates Rubidium atoms.
A cavity is necessary to enclose RF to act as magnetron that is perpendicular to the atomic Zeeman vector.

Advantages

① Design of cavity & lamp are classic and reliable compared to miniature Rb clock
② High reliability and maturity： 70% market occupancy including GPS, Glonass, Galileo, Compass
③ Low cost



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Conventional Rb Clock LPFRS (Switzerland)

Main Features:

- Very low temperature sensitivity
- Excellent short term stability
- Low power consumption
- Fast warm-up
- Small volume / low profile
- Rb with lamp extended life expectancy (20 years)
- Industry standard pin out
- RS 232 interface for centre frequency adjustment and monitoring of operation parameters

Conventional Rb Clock AR133A (Israel)

Main Features:

- Long-term-stability: 5E-11/month
- 2E-12 frequency accuracy & 100ns 1PPS accuracy relative to 1PPS input when disciplined
- Short term stability: 5E-12 @ 100s
- Phase noise: -150dBc/Hz @10kHz
- Outputs: 10 MHz and 1PPS
- Supply voltage: 15 VDC / 12 VDC (option)
- Steady state power < 8.25W
- Power-saving mode – < 1.8W Steady State (option)
- Size: 77 x 77 x 25.4 mm^3 (3” x 3” x 1”)

Our Conventional Rb Clock XHTF1031 (AXRB1031)

Main Features:

- Smallest Size: 51x 51 x 25 mm
- Long-term-stability: <5E-11/month,1E-9/year
- Wide operating temperature: -35℃~65℃
- RoHS compliant
- Outputs: 10 MHz sine wave/CMOS
- Supply voltage: 12 V to 15 V
- Steady state power consumption < 6W

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Comparison of Conventional Rb clocks

	vacuum sealing	size（mm）	power(w)（@25℃）	cost/price	reliability
LPFRS	NO	76×77× 36.5	10	high	medium
AR133A	NO	77 ×77× 25.4	7.5	medium	medium
XHTF1031	NO	51×51×25	5	medium	medium

Atomic Clock Production

- Top 1 with this ability in China (just below USA on a worldwide scale)
- Owns the complete Atomic Clock production equipment (see below)
- Owns vibration test platform and vacuum chambers to test Atomic Clocks

Filling equipment for Rb atoms

Vibration test platform

Temperature & humidity test chamber

Aging test line for Atomic Clocks

Hydrogen Atomic Clock

Hot vacuum set

Temperature test set