Quartzlock

Active Hydrogen Maser

PRECISE TIME & FREQUENCY STANDARD

- New Low Price
- Best Long Term Stability available
- New Autonomous Autotune Version
- Best Temperature Coefficient 5x10-16/°C
- World's Largest Installed Base >400 Units

CH1-75 May 2001

TECHNOLOGY

The CH1-75 principle of operation is based on a 5MHz quartz crystal oscillator, phase locked to the hyperfine transition of the hydrogen atom.
A basic block diagram of the Active Hydrogen Maser is shown in Figure 3
The atomic hydrogen signal generated in the physics package coupled to the synchronization unit.
The synchronization unit amplifies this signal (A) with the help of a superheterodyne receiver. This in turn synchronizes the 5MHz crystal oscillator signal phase producing the 5MHz & 100MHz spectrally-pure sinewave signal output. The frequency phase comparator in Figure 2, is designed to provide a very high resolution phase difference measurement using the Cavity Auto Tuning (CAT) system, which determines the frequency stability of the 100MHz externally applied signal (C). The 100MHz signal from the synchronization unit output (B) of the tuned maser is applied to the frequency comparator input along with the 100MHz signal from the second hydrogen maser (C) (used for CAT). The 100MHz signals are converted into a 1Hz signal (D) preserving the phase difference Df. cavity tuning provides Q-modulation of the hydrogen maser line. The reversible counter #1 counts the beat frequency of the two 100MHz signals during 100 seconds in the backward direction at another Q. The reversible counter #2 result (the difference of counting forward and backward) is proportional to Hydrogen Maser resonator frequency from the spectral line top frequency. The DAC output voltage is applied to the Hydrogen Maser cavity (E) varicap, to correct its frequency. Adjustments are made within cycles of 250 seconds. The frequency comparator and counter #1 control the frequency stability of the 100MHz external signal source (F).
These results are indicated on a digital display. Counter resolution is in the range of 1E-13 tp 1E-16 at measurement periods of 1 - 1000 seconds. Control and monitoring are accomplished via the IEC-625 bus (G).

FIGURE 1 SYNCHRONIZATION UNIT BLOCK DIAGRAM

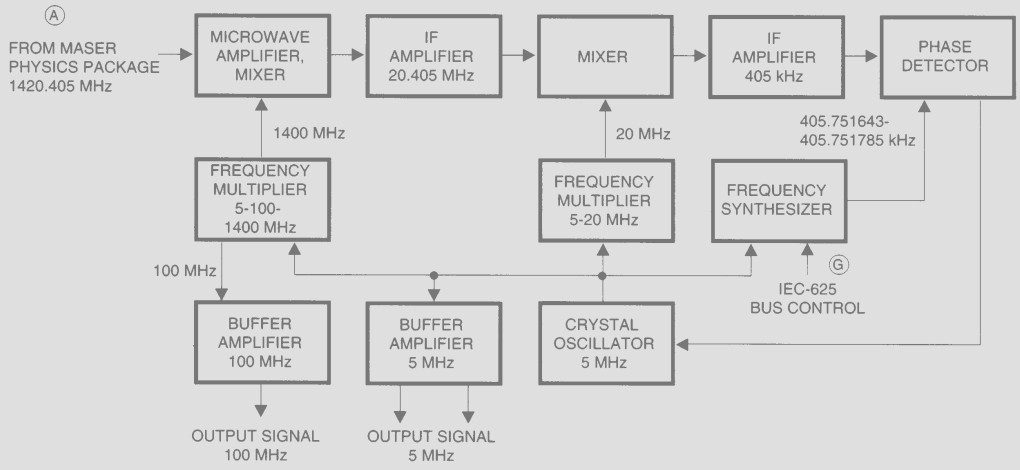


FIGURE 2 HYDROGEN MASER CAVITY AUTO TUNING (CAT MODE)

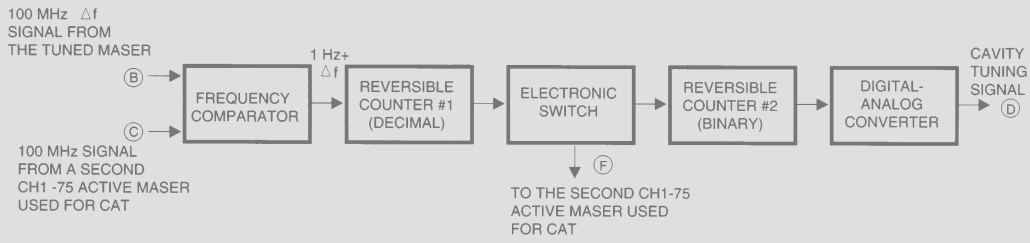


FIGURE 3 BLOCK DIAGRAM - ACTIVE HYDROGEN MASER

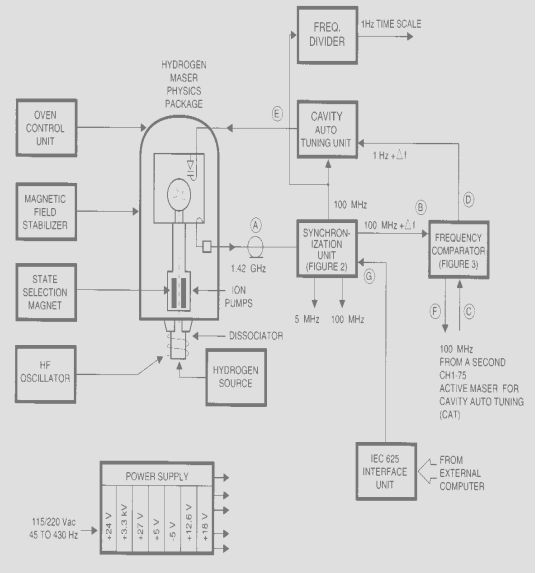


FIGURE 4 SECTIONAL VIEW OF THE HYDROGEN MASER PHYSICS PACKAGE

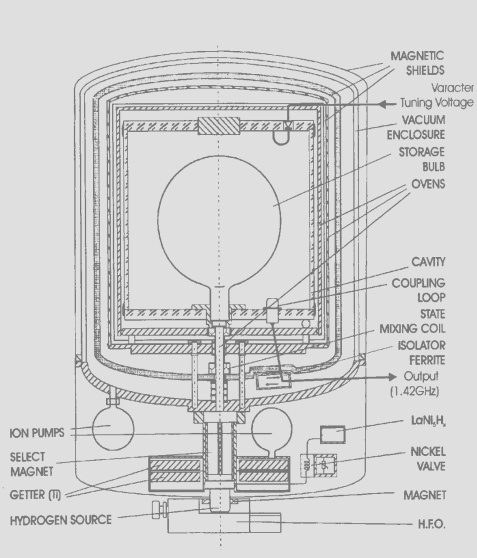
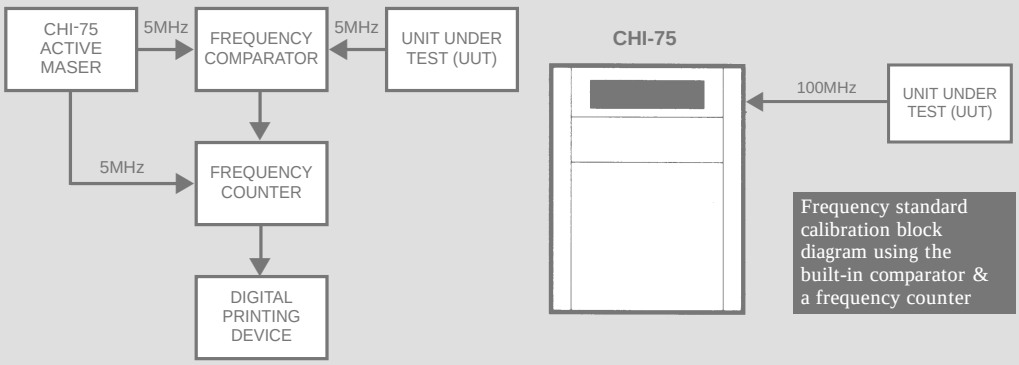


FIGURE 5 BLOCK DIAGRAMS FOR CALIBRATION



Frequency standard calibration block diagram using the built-in comparator & a frequency counter

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ISO 9001 · Craft Award 2000/2 · CE · NIST Traceable Standard · NPL Referenced · 5x dti Smart Awards

Quartzlock Active Hydrogen Maser CH1-75

TIME & FREQUENCY STANDARD

Frequency Outputs	(2) 5MHz, sine, 50 Ohms, 1±0.2 Vrms (2) 100MHz, 50 Ohms, 1±0.2 Vrms (2) 1Hz, (1 pps), 50 Ohms, >2.5V peak Pulse Width: 10 to 20ms Rise Time: ≤30ns Jitter: ≤100ps
Clock Synchronisation	Automatic within 50ns of ref. pulse Amplitude: 2.5 to 5V Width: 1 - 100ms Rise Time: ≤20ns Input Z: 50 Ohms

Stability

5MHz & 100MHz Allan Variance

Average Time (s)	σy(2,τ)		
	Without CAT	With CAT	Autonomous Auto Tune
1	≤2E-13	≤2E-13	≤3E-13
10	≤3E-14	≤3E-14	≤5E-14
100	≤5E-15	≤1E-14	≤1E-14
1000	≤2.5E-15	≤5E-15	≤5E-15
1h	≤1E-15	≤3E-15	≤3E-15
1 Day	≤1E-15	≤2E-15	≤5E-15

(Although this is a rugged instrument which operates within +5 to 35°C ambient, the quoted specifications apply while the instrument is confined to a ±1°C ambient temperature change)

Aging	No CAT ≤5E-15/Day at Delivery ≤3E-15/Day after 1 year operation	With CAT ≤5E-16/Day at Delivery ≤3E-16/Day after 1 year operation	Autonomous Auto Tune ≤5E-16/day at delivery ≤3E-16/day after 1 year operation
Accuracy	No CAT ≤3E-12 over a 1 year period	With CAT ≤5E-13 over a 5 year period	Autonomous Auto Tune 5E-13 over 5 years
Frequency Trim Range	At least 1E-10		
Setting Resolution	1E-14 Steps		
Retrace	No CAT ≤5E-13 after 24 hours of operation	With CAT ≤3E-14 after 24 hours of operation	

Phase Noise

SSB Phase Noise (dBc)		
Hz from carrier	5MHz outputs	100MHz outputs
1	-110	-95
10	-130	-105
100	-140	-115
1000	-150	-125
10000	-150	-125

Frequency Measurement Error (RMS) of Built-In Comparator	1E-13 per 1 sec 1.5E-14 per 10sec 3E-15 per 100sec 5E-16 per 1hr or more
Power Input - AC	115/220 Vac, ±10%, 45 to 430Hz <150 VA power consumption
Power Input - DC (automatic battery back-up)	As an alternative to ac the unit can be powered by an external 22-30 Vdc supply. <100 watts power consumption. In case of ac failure the instrument automatically switches to the dc input line
Warm-up Time	240 hours to meet specification
Operating Temperature	+5 to +35°C
Temperature Coefficient	No CAT ≤2E-15/°C With CAT 5E-16/°C Autonomous Auto Tune 5E-16/°C
Storage Temperature	-50°C to +50°C
Magnetic Sensitivity	≤1E-14/Oersted
Pressure	630 to 795 mm Hg
Humidity	Up to 80% at 25°C
Size	27”H x 19”W x 22”D (68cm x 48cm x 56cm)
Weight	210lbs (90kg)
Warranty	1 year Long Term Service Contracts Available
Service Life	10 years minimun

TIME & FREQUENCY STANDARD

INTRODUCTION

The Active Hydrogen Maser technology provides the best known frequency stability for a frequency standard commercially available today.
Active masers will be used when the best stability is needed in a time domain of 1 sec, to a day. At a 1-hour averaging time, the Active Maser exceeds the stability of the best known cesium oscillators by a factor of at least 100 (Figure 1). Unlike cesium oscillators, Hydrogen Masers have much less physics wear-out mechanism. They have the inherent ability to operate for over 10 years. The dissociator will last for 10 years or more and can be changed at a cost of very much less than the cesium beam tube in a cesium standard. The Active Maser is a rugged laboratory instrument, requiring no special environmental conditioning. If state of the art accuracy is needed in addition to the best frequency stability, two Active Masers can be coupled in Cavity Auto Tuning mode (CAT) to obtain parts in 10^{13}/year stability as described here.

APPLICATIONS

- National Timekeeping
- National Frequency Standards
- VLBI
- Deep Space Navigation
- Fountain Cesium Reference
- Navigation
- Telecommunications
- GNS Ground Control
- GPS Satellite Monitoring
- Astro Laser Rangefinding
- Astronomy
- Baseline Definition
- Calibration
- Calibration of Cesium and Rubidium
- Climatology
- Defence
- Determination of Earth rotation
- Earthquake Research
- Fast Missile Tracking
- Geodesy
- Geodynamics
- Glacial Movement
- Gravity Prospecting
- Intelligence
- Plate Tectonics
- Position Fixing
- Secure Communications
- Space Navigation
- Support of Radar

SOLUTIONS

- 24/48 Hour Call Out
- Advice: Feasibility Studies
- Cables and Connectors
- Calibration
- Calibration & Certification of Accuracy
- Certification
- Commissioning
- Custom Design
- Delivery - Worldwide
- Design Definition - Customer Liaison
- Development
- Documentation
- Field Trials
- Finance
- In-House Test
- Installation
- Insurance
- Jigs and Fixtures
- Maintenance Contract (with spares)
- Maintenance Contract (without spares)
- On-Site Measurements
- Presentation/Education
- Production of Special Systems
- Quality Assurance ISO9001 EN29001
- Service Facility
- Spare Parts/Modules
- Training
- Unique Traceability
- Upgrades

FIGURE 4 ALLAN VARIANCE COMPARISON OF CESIUM WITH H-MASERS