



## Russian Hydrogen Masers For Ground And Space Applications

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Active and passive hydrogen masers developed and manufactured by Russian company "Vremya-CH" are widely used over the world in scientific laboratories, radio astronomy observatories, national time keeping services and telecommunication systems.

The feature of the active masers is a cavity auto tuning (CAT) system using the microwave cavity resonant frequency switching technique. Such CAT operation does not degrade short-term stability and allows achieving the long-term stability  $3\div 5 \times 10^{-16}$  at one day. At the same time, a new commercial passive hydrogen maser using the digital signal processing has frequency stability  $5 \times 10^{-13}$  at one second and  $2\div 3 \times 10^{-15}$  at one day.

Almost seven years ago, the first active hydrogen maser designed for long-term use in orbit was launched on board the space radio telescope "Spektr-R". Having 3 years designated lifetime it is still working nowadays ensuring the successful implementation of an international space VLBI project RadioAstron.

Another space atomic clock was developed on the base of passive hydrogen maser by "Vremya-CH" company within the framework of GLONASS program. Its long-term frequency stability better than  $5 \times 10^{-15}$  @ 1 day is confirmed by two-years long laboratory tests. This improved performance comparing to the existing on-board clocks will allow to improve GLONASS-based timing and positioning in the near future.

A new active hydrogen masers generation for space observatory "Millimetron" (project "Spectrum-M") is under development now. This mission will enable astronomers to observe the Universe with unprecedented sensitivity and angular resolution.

Listed above hydrogen masers design features, specifications, ground and in-orbit testing results are presented.