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To whom it may concern,

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Notice on Success of Development of the Next Generation High-frequency Oscillator Using Miniature Atomic Clock

Please be informed that we have succeeded in development of the next generation high-frequency oscillator by embedding high-frequency crystal oscillator (*1) into the small atomic clock with cooperation of Tohoku University.

1. Background

As announced in “Notice on Commencement of Joint Research with Tohoku University (Sendai City, Miyagi Pref.)” dated February 14, 2019, we have proceeded with the joint research with the researcher Yasubumi Furuya / Tohoku University, Micro System Integration Center (former specially-appointed professor) as the research representative for the research and development of optimizing device control / monitoring system of surplus power, which is expected to be used in the natural energy (solar, wind, biomass, hot spring heat, etc.) field.

In addition, as announced in “Commencement of Research on Application Using a Miniature Atomic Clock and Atomic Clock” dated July 6, 2020, we have also been proceeding with the joint research of the application using the miniature atomic clock and atomic clock with Professor Takahito Ono of School of Engineering, Tohoku University as the research representative.

With support in both joint researches, etc., we have proceeded with consideration of low consumption high-frequency oscillator, which is the core of high-frequency optic/wireless communication devices in the next generation communication.

2. About this development

With the perspective of Society 5.0 and post Covid-19 world, while digital transformation (DX) of the society and industry is accelerated, greater capacity and further sophistication are currently expected in the communication infrastructure which is the platform to connect tremendous amount of data with people and things as the contact point.

Atomic clocks used for the satellites, planetary exploration spacecrafts and communication base stations, etc. synchronize GPS (Global Positioning System) signals with UTC (Universal Time Coordinated) when used as clock synchronization and can further reduce delay of transmission and reception time of the signals between multiple base stations, etc. and between terminals. For the conventional atomic clocks, 10MHz quartz crystal is used for VCO (voltage controlled oscillator (*2)) which transmits the reference clock signals, of which frequency is low compared to the recent 5G/6G high-frequency communication.

We have developed the high-frequency oscillator (Figure 1) with 640MHz quartz crystal embedded, which has the property of temperature stability up to higher frequency, and succeeded in making the reference clock frequency as 64 times as the conventional frequency. This enables highly delicate high-frequency communication with controlled jitter noise created by frequency drift.

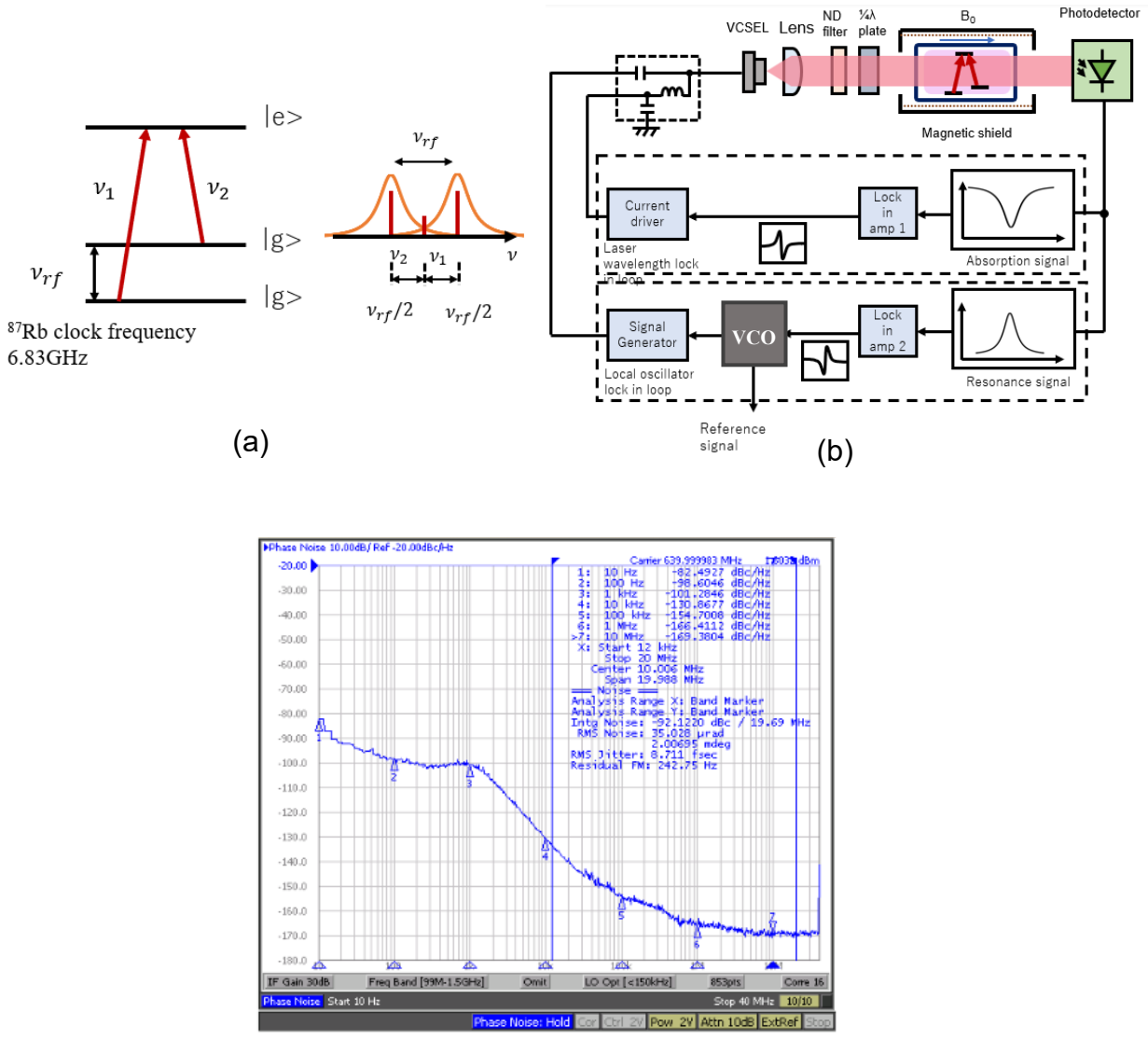

Figure 1. Principle of the developed high-frequency oscillator and measurement result of phase noise of the high-frequency oscillator for 5G/6G measured with frequency analyzation equipment

(a) Explanation of CPT(Coherent Population Trapping) resonance which is quantum-optical phenomenon. Energy between the ground levels has extremely stable property specific to atom. In case of 87Rb, it is 6.83GHz if converted as frequency, and the stable clock is created by converting such energy difference into electric signals with laser to make oscillation clock of quartz crystal.

(b) Outlined block diagram of high-frequency oscillator using the voltage controlled oscillator of high-frequency oscillation. It is the design compatible with high-frequency communication by using crystal oscillator of which basic mode is 640MHz, 64 times as high as the conventional 10MHz for VCO which extracts the reference electric signals.

(c) 8.7 femtosecond, the world's top class was achieved for RMS jitter noise (12 kHz – 20 MHz) from the phase noise measurement (Vertical axis: Noise ratio [dB], Horizontal axis: Frequency [Hz]).

3. Future approaches

With this development as the starting point, we will accelerate development of the communication devices of high-frequency bandwidth which is essential for realization of the social base construction to unify the government-promoted next generation communication / digital high-speed processing technology (highly accurate automatic driving, robot control, higher-security electronic payment, etc.) and digital rural city (smart city) conception and contribute to further building of safety and reliability of the next-generation infrastructure.

<Terminology>

*1: A quartz crystal is one of the active elements that cause oscillation of high frequency accuracy by using the piezoelectric effect of crystal (quartz). It is the essential part for electronics of the present time such as quartz clock, wireless communication, computer, etc.

*2: VCO stands for voltage controlled oscillator. An oscillator that controls oscillation frequency by voltage. See Figure 1.

【Technical inquiries】

Management Planning Division: Nishino

Access the inquiry form below.

https://www.tmex.co.jp/tech_inq/