

Cs FREQUENCY SYNTHESIS: A NEW APPROACH

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ABSTRACT

This paper describes a new approach to synthesizing the Cs hyperfine frequency of 9.192 GHz that is designed to be sufficiently rugged for use in space, specifically for the primary atomic reference clock in space (PARCS) planned for the international space station, as well as ground applications. This new approach requires no narrow band filters or frequency multiplication and the primary source of cooling is conduction. Instead of frequency multiplication, it uses a custom regenerative divider stage followed by two commercial binary dividers and several mixing stages. A fractional frequency step of 2×10^{-14} is achieved by mixing the output of a 48 bit numerically controlled oscillator with the microwave signal. Preliminary tests on the new synthesizer design indicate an internal fractional frequency stability of 1×10^{-13} at 10 s and 1×10^{-14} at 1 day, dominated by the daily room temperature variations. The phase and amplitude noise are similar to our previous designs that used frequency multiplication and narrow band filters. The temperature coefficient is less than $0.2 \text{ ps/}^\circ\text{C}$.

1. INTRODUCTION

Within the last decade new generations of frequency standards based on laser cooled atoms and ions with stabilities approaching 10^{-16} at 1 day have been developed [1-3]. At these stabilities, the performance of the local oscillator and the microwave synthesis chain appear to be limiting factors. To support NIST's new standards, we have designed a new generation of microwave frequency synthesizers [4-6]. The basic criteria for these designs have been high resolution, low phase modulation (PM) and amplitude modulation (AM) noise, low spurs near the carrier, and very high phase stability with respect to environmental effects.

The aim of the present work was to design a microwave synthesizer for a laser cooled Cs fountain compatible for use in space, specifically for a slow beam Cs primary atomic reference clock in space (PARCS) scheduled for flight the international space

station [7]. This required the use of components that are or can be space-qualified. Other major design goals were that the synthesizer be compact, robust, consume low power, and very importantly, that all dissipated heat be removed by conduction and radiation as there is minimal convection in space. The performance goal was a frequency resolution of at least 10^{-13} and a fractional frequency stability at 1 day of lower than 1×10^{-14} .

In the following section we describe our design. The approach yields a simple synthesis scheme that avoids frequency multiplication, narrow band filters, and phase-locked loops while still producing an output that is suitable with high resolution. We also discuss some initial performance results of the two units that were constructed. All performance goals were met or exceeded.

2. DESIGN DETAILS

Figure 1 shows a schematic block diagram of the synthesizer. The output of a 6.4 GHz voltage-controlled dielectric resonant oscillator (DRO) drives a custom regenerative divide-by-2 circuit [8], comprised of a mixer, a 3.2 GHz low-pass filter, and an amplifier in a closed-loop configuration. This regenerative divider provides low PM noise [9], a very low coefficient of phase shift with temperature, and simultaneous outputs at 0.5 and 1.5 times the input frequency, i.e., at 3.2 GHz and 9.6 GHz. The 3.2 GHz and 9.6 GHz outputs are separated using a diplexer.

The 3.2 GHz output is divided to 100 MHz using a commercial divide-by-8 followed by a commercial divide-by-4 [10]. The 100 MHz output of the dividers is low-pass filtered and buffered in a two-stage amplifier to provide the output reference frequency.

Another key constituent of the synthesizer is a numerically controlled oscillator using a direct digital synthesis (DDS) chip with 48 bit resolution [11]. This unit is clocked by a 50 MHz signal obtained by dividing the 100 MHz by 2. This DDS chip not only provides the high resolution and low spurs, but it is also available in a space-qualified version. The DDS output is a sine wave, which can be set to a resolution of 0.2 μHz and a rate up to 20 MHz using 14 data and control lines. Another feature of this DDS is that its frequency

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Second International Conference On Frequency Control And Synthesis

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The Navstar Global Positioning System Tom Logsdon,2012-12-06 Detecting and Classifying Low Probability of Intercept Radar Phillip E. Pace,2009 This comprehensive book presents LPI radar design essentials including ambiguity analysis of LPI waveforms FMCW radar and phase shift and frequency shift keying techniques Moreover you find details on new OTHR modulation schemes noise radar and spatial multiple input multiple output MIMO systems The book explores autonomous non linear classification signal processing algorithms for identifying LPI modulations It also demonstrates four intercept receiver signal processing techniques for LPI radar detection that helps you determine which time frequency bi frequency technique best suits any LPI modulation of interest Publisher *Direct Digital Frequency Synthesizers* Venceslav F. Kroupa,1998-11-18 With the advent of integrated circuits IC digital systems have become widely used in modern electronic devices including communications and measurement equipment Direct Digital Frequency Synthesizers DDS are used in communications as transmitter exciters and local oscillators in receivers The advantages are superior frequency stability the

same as that of the driving clock oscillator and short switching times The difficulties are lower output frequencies and rather large spurious signals Compiled for practicing engineers who do not have the prerequisite of a specialist's knowledge in Direct Digital Frequency Synthesizers DDS this collection of 40 important reprinted papers and 9 never before published contributions presents a comprehensive introduction to DDS properties and a clear understanding of actual devices The information in this volume can lead to easier computer simulations and improved designs Featured topics include Discussion of principles and state of the art of wide range DDS Investigation of spurious signals in DDS Combination of DDS with Phase Lock Loops PLL Examination of phase and background noise in DDS Introduction to Digital to Analog Conversion DAC Analysis of mathematics of quasiperiodic omission of pulses DDFS can also serve as a textbook for students seeking essential background theory

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the essence of developments of Gallium Arsenide technology from the research laboratory to the marketplace along with the dramatic increases in complexity from early single devices to ICs of MSI complexity for both analog and digital applications

Proceedings of 2nd International Conference on Micro-Electronics, Electromagnetics and Telecommunications Suresh Chandra Satapathy,Vikrant Bhateja,P. Satish Rama Chowdary,V.V.S.S. Sameer Chakravarthy,Jaume Anguera,2017-09-06 The book is a collection of best papers presented in the Second International Conference on Microelectronics Electromagnetics and Telecommunication ICMEET 2016 an international colloquium which aims to bring together academic scientists researchers and research scholars to discuss the recent developments and future trends in the fields of microelectronics electromagnetics and telecommunication Microelectronics research investigates semiconductor materials and device physics for developing electronic devices and integrated circuits with data energy efficient performance in terms of speed power consumption and functionality The book discusses various topics like analog digital and mixed signal circuits bio medical circuits and systems RF circuit design microwave and millimeter wave circuits green circuits and systems analog and digital signal processing nano electronics and giga scale systems VLSI circuits and systems SoC and NoC MEMS and NEMS VLSI digital signal processing wireless communications cognitive radio and data communication **Second International Conference on Power Electronics, Machines, and Drives (PEMD 2004)** ,2004 **Conference Publication** ,1989

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