# **Gps Clock**

Dan Doberstein

GPS Clock Technology and the Navy PTTI Programs at the U.S. Naval Research Laboratory, 1986 For many years, the Naval Research Laboratory (NRL) has been improving the Navy's capability in space systems for navigation and precise timing, frequently in conjunction with the U.S. Naval Observatory. We will briefly summarize NRL's work from tracking the earliest satellites through our part in developing the Global Positioning System (GPS). Currently, the GPS Clock Technology Program at NRL includes research into the design of atomic clocks for space and terrestrial use, technical management of contractual efforts to build space clocks for use on GPS spacecraft and the GPS Master Control Stations, operation of a sophisticated clock test facility, design of a remote timing station for the GPS Colorado Springs Operations Center, and coordination on timing related functions of the GPS user equipment. NRL is also involved in support of PTTI applications in other Navy programs. A brief summary of these will be included.

Performance of new GNSS satellite clocks Gonzalez Martinez, Francisco Javier, 2013-12-24

Rubidium Atomic Clock: The Workhorse Of Satellite Navigation G M Saxena, Bikash Ghosal, 2020-03-05 The Rubidium atomic clock (Rb) is the workhorse of the satellite navigation systems of which GPS is now a household name. With just the tap of a few keys, drivers and navigators all over the world are able to reach their destination effortlessly with high precision. People are now curious to know what makes this possible. Hence, the need to explain in simplistic terms the Rb atomic clocks that are onboard these satellite navigation systems because no good satellite navigation system is possible without such clocks. But why only Rb atomic clocks when far better and exotic atomic clocks are available? The reasons are as simple as that they are slim, low in weight, easy to build inexpensively. They are also used in numerous military applications such as secure communications, electronic warfare, command and control, telemetry and navigation. Besides, they are used in the measurements of the variation in fine-structure constant, test of relativity, precise spectroscopy and scientific research. This book details the history of time keeping and the chronological development of the Rb atomic clocks, with special focus on the physics Package that accounts for the actual performance of the clock. Researchers and industrialists will find that producing such clocks is relatively simple and inexpensive.

Time and Navigation Andrew K. Johnston, Roger D. Connor, Carlene E. Stephens, Paul E. Ceruzzi, 2015-06-02 If you want to know where you are, you need a good clock. The surprising connection between time and place is explored in Time and Navigation: The Untold Story of Getting from Here to There, the companion book to the National Air and Space Museum exhibition of the same name. Today we use smartphones and GPS, but navigating has not always been so easy. The oldest clock is Earth itself, and the oldest means of keeping time came from observing changes in the sky. Early mariners like the Vikings accomplished amazing feats of navigation without using clocks at all. Pioneering seafarers in the Age of Exploration used dead reckoning and celestial navigation; later innovations such as sextants and marine chronometers honed these techniques by measuring latitude and longitude. When explorers turned their sights to the skies, they built on what had been learned at sea. For example, Charles Lindbergh used a bubble sextant on his record-breaking flights. World War II led to the development of new flight technologies, notably radio navigation, since celestial navigation was not suited for all-weather military operations. These forms of navigation were extended and enhanced when explorers began guiding spacecraft into space and across the solar system. Astronauts combined celestial navigation technology with radio transmissions. The development of the atomic clock revolutionized space flight because it could measure billionths of a second, thereby allowing mission teams to navigate more accurately. Scientists and engineers applied these technologies to navigation on earth to develop space-based time and navigation services such as GPS that is used every day by people from all walks of life. While the history of navigation is one of constant change and innovation, it is also one of remarkable continuity. Time and Navigation tells the story of navigation to help us understand where we have been and how we got there so that

Fast Direct-P(Y) GPS Signal Acquisition Using a Special Portable Clock ,2002 What goes around comes around, we have heard it said, and it seems that this is the case for precision Portable Clocks as well. Twenty years ago, the only effective way to transfer Universal Coordinated Time (UTC) from one geographic location to another was with a Portable Clock. Since the advent of GPS however, UTC dissemination is done via satellites, virtually eliminating Portable Clocks. But now a new element is looming on the horizon, which may breathe new life into applications of such devices. This relates to the GPS P(Y)-Code, which is the secure military crypto-keyed signal providing what is referred to as the Precise Positioning Service (PPS). More specifically, however, is what a Portable Clock can do to enhance the new functionality of the P(Y)-Code signal acquisition called Direct-P(Y), in an environment where the civil C/A-Code signal is not available. Direct-P(Y) refers to the ability for the military receiver to come online without the aid of the civil (in the clear) C/A-Code signal. The Portable Clock can play an important role in quick acquisition of the P(Y)-Code signal, a significant crew safety consideration for our soldiers in the field. No matter what the operational scenario may be, the Portable Clock proves to be an invaluable tool for Direct-P(Y) terminals. For those about to enter hostile territory, no-one should leave home without one.

Fundamentals of GPS Receivers Dan Doberstein, 2011-10-22 Fundamentals of GPS receivers covers GPS receivers' theory and practice. The book begins with the basics of GPS receiver and moves onward to more advanced material. The book examines three types of GPS receiver implementations: first is the custom design by the author; second is an industry standard design, now part of the open source network; the third relates to the receiver designed by JPL /NASA. Each receiver is unique allowing the reader to see how each design solves the same problems. Chapters discuss carrier phase measurements and GPS time and frequency measurements. The overall text is measurement oriented as opposed to processing the measurements. With a focus on the fundamentals of measurements the reader will be building their intuition for the physical phenomenon at work.

GPS-based Optimal FIR Filtering of Clock Models Yuriy Shmaliy,2009 This book addresses novel results in the field of optimal finite impulse response (FIR) estimation and steering of the local clock time errors using the Global Positioning System (GPS) timing signals. The studies are motivated by permanently increased demands for accuracy of the local timescales in different areas of applications of wire and wireless digital systems. The main limitations of accuracy here are the GPS time uncertainty caused by different satellites in a view and the sawtooth noise induced by the commercially available GPS timing receivers owing to the principle of the one pulse per second (1PPS) signal formation. Due to the GPS time uncertainty, flicker components of the clock noise, and non Gaussian sawtooth noise, the

standard Kalman algorithms may become unstable and noisy, even when the sawtooth correction is applied. We show that an efficient way of providing stable and accurate filtering, smoothing, prediction, and steering of the local clock errors is to use the optimal FIR structures, which are inherently bounded input/bounded output (BIBO) stable and more robust against temporary uncertainties and round-off errors. Moreover, unbiased polynomial FIR solutions having strong engineering features become actually optimal by large averaging horizons typically used in timekeeping. Such solutions are found and investigated in detail theoretically and for real measurements. Based upon, it is stated that optimal (unbiased) FIR estimators are likely the best candidates to use in the modern filtering, prediction, and synchronisations algorithms intended for the estimation and steering of local clocks.

Long-Term Clock Behavior of GPS IIR Satellites ,2007 The ITT-developed GPS IIR satellite payloads have been on orbit since 1997, and have proven to be the best family of clocks in the GPS constellation. At this time, there is a substantial recorded history of clock behavior, including over 60 clock years of space operation. The age of the oldest clock is over 9 years. A review of the record shows a number of significant characteristics that were not apparent in shorter clock tests. Rubidium clocks, as opposed to cesium clocks, have significant long-term drift. The current literature describes an initial model of drift aging for rubidium atomic clocks followed by a long-term dracteristic. A review of the IIR clocks shows what appears to be another significant break point in the long-term drift characteristics. The usual assumption is that the drift tends toward zero drift in the long term. The data indicate that the long-term drift will always remain negative and stay substantially away from zero. It is commonly known that some rubidium clocks generate frequency steps and the frequency steps tend to decrease in size and rate of occurrence over time. We have seen a number of cases of this behavior. Most frequency steps tend to be frequency steps that tend to persist in time, but we also have seen triangular frequency patterns where a sudden jump in frequency is followed by a rapid decay to the long-term drift pattern. Also, we have cases in which a frequency step pattern that has persisted for a significant time suddenly disappears. Although there are cases where the frequency step intensity initially grows after turn-on, the overall pattern is for the frequency step intensity to decay over the long term. Future observations of these clocks will allow us to determine if this decay in frequency step intensity is permanent.

GPS Satellite Clock Estimation Every 30 Seconds and Application to Accurate Absolute Positioning ,1998 This report presents the results of investigations to determine very accurate position coordinates using the Global Positioning System in the absolute (point) positioning mode. The most common method to obtain very accurate positions with GPS is to apply double-differencing procedures whereby GPS satellite signals are differenced at a station and these differences are again differenced with analogous differences at other stations. The differencing between satellites eliminates the large receiver clock errors, while the between-station differences eliminate the large satellite clock errors (as well as some other errors, such as orbit error). However, only coordinate differences can be determined in this way and the accuracy depends on the baseline length between cooperating stations. The strategy with accurate point positioning is to estimate GPS satellite clock errors independently, thus obviating the between-station differencing. The clock error estimates are then used in an application of a single-difference (between-satellite) positioning algorithm at any site to determine the coordinates without reference to any other site. Using IGS orbits and stations, the GPS clock errors were estimated at 30-second intervals and these estimates were compared to values determined by JPL. The agreement was at the level of about 0.1 nsec (3 cm). The absolute positioning technique was tested at a stationary site (IGS station) whose coordinates are known. The differences between the estimated absolute position coordinates and the known values had a standard deviation less than 4 cm in all three dimensions, with mean differences ranging from 3.4 cm to 6.3 cm.

Development and Evaluation of GPS Space Clocks for GPS III and Beyond ,2001 The current GPS has exceeded its globally averaged position and timing accuracy of 16 m (50 YO spherical error) and 100 ns (1 U) as stated in the 1990 GPS System Operation Requirements Document (SORD). The 1999 GPS Operational Requirements Documents (ORD) set a new goalfor the GPS ZZZ and beyond. The 1999 ORD specifies the ranging accuracy 1.5 m threshold and 0.5 m objective. The 95% time transfer accuracy threshold and objective are 20 ns and 10 ns, respectively. This paper will evaluate how the current clocks and the clocks being developed can support the ORD threshold and objective. The paper will include the following topics: (1) atomic clocks on the GPS Block ZZ space vehicles, (2) estimated accuracy of the ZZF Rb clock by Perkin Elmer and digital Cs clock by Datum-Beverly and assessment of their performance against the ORD threshold range requirements, (3) description of the new space clocks being developed jointly by the GPS JPO, Aerospace, and NRL, and evaluation of their predicted pe6ormunce to see if they can support the ORD objective of 0.5 m (rms), and (4) Prediction of the GPS signul-in-space accuracy, including all the space and control segments errors, using ZZF Rb and Cs clocks. The predictions are based on replacing the NZMA estimated GPS ZZ/IZA/ZZR clock data, contained in the actual tracking data of the GPS monitor stations and the NlMA tracking stations, by simulated IZF Rb and Cs clock data. A Kalman filter similar to that of the OCS then processes the resulting tracking data and the estimated results are compared with NIMA estimates treated as truth. Evaluations of the various options to see whether the ORD objective can be achieved based on the predicted signal-in-space accuracy are included.

A <u>Summary of the GPS Constellation Clock Performance</u>, 2007 The Naval Research Laboratory (NRL) conducts comprehensive analyses of the Global Positioning System (GPS) atomic frequency standards under the sponsorship of the 2nd Space Operations Squadron (2SOPS) at the Master Control Station (MCS) in Colorado Springs, Colorado. The analysis is based on clock estimates that NRL computes from GPS monitor station carrier-derived pseudo-range measurements and National Geospatial-Intelligence Agency (NGA) computed precise post-fit orbit ephemerides. The purpose of the analyses is to determine the performance of the timing signals originating from the atomic frequency standards onboard the space vehicles. Metrics used in the analyses include frequency, drift, stability profiles, and stability histories based on the Allan and Hadamard variances. The relative performance of the space vehicle clocks is ranked and presented according to the clock types flown in GPS. An overview of the GPS constellation with respect to the lifetimes of space vehicles and space vehicle clocks, both active and deactivated, is also presented.

Hacking GPS Kathie Kingsley-Hughes,2005-03-25 \* This is the user manual that didn't come with any of the 30 million GPS receivers currently in use, showing readers how to modify, tweak, and hack their GPS to take it to new levels! \* Crazy-cool modifications include exploiting secret keycodes, revealing hidden features, building power cords and cables, hacking the battery and antenna, protecting a GPS from impact and falls, making a screen protector, and solar-powering a GPS \* Potential power

users will take the function and performance of their GPS to a whole new level by hacking into the firmware and hacking into a PC connection with a GPS \* Fear not! Any potentially dangerous mod (to the device) is clearly labeled, with precautions listed that should be taken \* Game time! Readers can check out GPS games, check into hacking geocaching, and even use a GPS as a metal detector

Uncertainties in GPS Positioning Alan Oxley,2017-01-17 Uncertainties in GPS Positioning: A Mathematical Discourse describes the calculations performed by a GPS receiver and the problems associated with ensuring that the derived location is a close match to the actual location. Inaccuracies in calculating a location can have serious repercussions, so this book is a timely source for information on this rapidly evolving technology. Covers how a GPS receiver works and how the earth is modeled so position data can be calculated Discusses the different signals and clock speeds of the satellites, the receivers, and sources of inaccuracy Examines how the errors are distributed in the data and provides examples

### 20th Natural Philosophy Alliance Proceedings David de Hilster,

Clock Synchronization and Navigation in the Vicinity of the Earth Thomas Bazyli Bahder, 2009 Clock synchronisation is the backbone of applications such as high-accuracy satellite navigation, geolocation, space-based interferometry, and cryptographic communication systems. The high accuracy of synchronisation needed over satellite-to-ground and satellite-to-satellite distances requires the use of general relativistic concepts. The role of geometrical optics and antenna phase centre approximations are discussed in high accuracy work. The clock synchronisation problem is explored from a general relativistic point of view, with emphasis on the local measurement process and the use of the tetrad formalism as the correct model of relativistic measurements. The treatment makes use of J. L. Synge's world function of space-time as a basic co-ordinate independent geometric concept. A metric is used for space-time in the vicinity of the Earth, where co-ordinate time is proper time on the geoid. The problem of satellite clock syntonisation is analysed by numerically integrating the geodesic equations of motion for low-Earth orbit (LEO), geosynchronous orbit (GEO), and highly elliptical orbit (HEO) satellites. Proper time minus co-ordinate time is computed for satellites in these orbital regimes. The frequency shift as a function of time is computed for a signal observed on the Earth's geoid from a LEO, GEO, and HEO satellite. Finally, the problem of geolocation in curved space-time is briefly explored using the world function formalism.

<u>GNSS Remote Sensing</u> Shuanggen Jin, Estel Cardellach, Feiqin Xie, 2013-10-01 The versatile and available GNSS signals can detect the Earth's surface environments as a new, highly precise, continuous, all-weather and near-real-time remote sensing tool. This book presents the theory and methods of GNSS remote sensing as well as its applications in the atmosphere, oceans, land and hydrology. Ground-based atmospheric sensing, space-borne atmospheric sensing, reflectometry, ocean remote sensing, hydrology sensing as well as cryosphere sensing with the GNSS will be discussed per chapter in the book.

China Satellite Navigation Conference (CSNC) 2017 Proceedings: Volume III Jiadong Sun, Jingnan Liu, Yuanxi Yang, Shiwei Fan, Wenxian Yu, 2017-05-02 These proceedings present selected research papers from CSNC2017, held during 23th-25th May in Shanghai, China. The theme of CSNC2017 is Positioning, Connecting All. These papers discuss the technologies and applications of the Global Navigation Satellite System (GNSS), and the latest progress made in the China BeiDou System (BDS) especially. They are divided into 12 topics to match the corresponding sessions in CSNC2017, which broadly covered key topics in GNSS. Readers can learn about the BDS and keep abreast of the latest advances in GNSS techniques and applications.

**Einstein, Relativity and Absolute Simultaneity** William Lane Craig, Quentin Smith, 2007-11-08 Einstein, Relativity and Absolute Simultaneity is an anthology of original essays by an international team of leading philosophers and physicists who have come together to reassess the contemporary paradigm of the relativistic concept of time. A great deal has changed since 1905 when Einstein proposed his Special Theory of Relativity, and this book offers a fresh reassessment of Special Relativity's relativistic concept of time in terms of epistemology, metaphysics, and physics.

Astroquizzical Jillian Scudder, 2018-03-08 In this enthralling cosmic journey through space and time, astrophysicist Jillian Scudder locates our home planet within its own 'family tree'. Our parent the Earth and its sibling planets in our solar system formed within the same gas cloud. Without our grandparent the Sun, we would not exist, and the Sun in turn relies on the Milky Way as its home. The Milky Way rests in a larger web of galaxies that traces its origins right back to tiny fluctuations in the very early universe. Following these cosmic connections, we discover the many ties that bind us to our universe. Based around readers' questions from the author's popular blog 'Astroquizzical', the book provides a quirky guide to how things work in the universe and why things are the way they are, from shooting stars on Earth, to black holes, to entire galaxies. For anyone interested in the 'big picture' of how the cosmos functions and how it is all connected, Jillian Scudder is the perfect guide.

<u>Earth Observation with CHAMP</u> Christoph Reigber, Hermann Lühr, Peter Schwintzer, Jens Wickert, 2005-12-27 In the summer of 2000 the German geo-research satellite CHAMP was launched into orbit. Its innovative payload arrangement and the low initial orbit allow CHAMP to simultaneously collect and almost continuously analyse precise data relating to gravity and magnetic fields at low altitude. In addition, CHAMP also measures the neutral atmosphere and ionosphere using GPS techniques. Three years after launch, more than 200 CHAMP investigators and co-investigators from all over the world met at the GeoForschungsZentrum in Potsdam to present and discuss the results derived from the extensive data sets of the mission. The main outcome of this expert meeting is summarized in this volume. The book offers a comprehensive insight into the present status of the exploitation of CHAMP data for Earth system research and practical applications in geodesy, geophysics and meteorology.

#### **Gps Clock** Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its ability to stir emotions, provoke thought, and instigate transformation is actually remarkable. This extraordinary book, aptly titled "Gps Clock," compiled by a highly acclaimed author,

immerses readers in a captivating exploration of the significance of language and its profound impact on our existence. Throughout this critique, we shall delve to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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