

SCANNING THE ISSUE: SPECIAL ISSUE ON TIME  
AND FREQUENCY

BY

J. L. JESPERSEN, B. E. BLAIR, AND L. E. GATTERER

*Reprinted from* PROCEEDINGS OF THE IEEE  
VOL. 60, NO. 5, MAY, 1972  
pp. 476-478

COPYRIGHT © 1972—THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.  
PRINTED IN THE U.S.A.

# Scanning the Issue

## SPECIAL ISSUE ON TIME AND FREQUENCY

Standard time and frequency broadcast services have been in operation for over half a century. The commercial radio broadcast industry was an early customer for these services; in those days the state of the oscillator art was such that it was not easy for the broadcasters to stay on their assigned frequencies in a crowded spectrum. When the dirigible *Shenandoah* became lost during a winter storm in the early 1920's, all New York radio stations ceased transmissions so that the lost ship's messages could be detected.

Over the years the standard broadcast formats evolved to meet changing user needs, and the frequency stability of the reference time standard improved. The propagation medium did not change, however, so the propagation delay stability at high frequency (HF) is no better today than it was 50 years ago although HF signals are still useful. This propagation factor was of little consequence as long as the reference time standard was less stable than the HF propagation medium, but those days are gone. Systems are now being considered in different frequency bands that can take full advantage of the timekeeping capabilities of today's commercially available atomic clocks. But even atomic clocks have limits to their stability and reliability, and confidence in a system is enhanced if its clocks can be checked at will. Thus there is strong incentive to provide very accurate time services.

In recent years, researchers have experimented with a wide variety of new time and frequency dissemination techniques. Much attention has been focused on the opportunities for exploiting the dissemination capabilities of existing communication and navigation systems that exhibit high stability. Two notable examples are the commercial television network and the Loran-C navigation system. Neither was designed with time dissemination in mind, but both have important capabilities. On the other hand, the formats of TV and Loran-C are not the most convenient to use for this purpose; however, they can be and are so employed.

Time and its counterpart, frequency, are fundamental building blocks of electromagnetic systems; radio navigation systems depend on the notion that distance and time are related by a constant, and every communication system requires that the transmitter and the receiver be synchronized in frequency and at least coarsely in time. About 20 percent of the usable television bandwidth is devoted to keeping oscillators and pulse trains in television receivers aligned; and it is done independently on every channel.

Communication systems are often designed with built-in "single-customer" synchronization services. Significantly, many "single-customer" dissemination services are designed and implemented without conscious recognition by the designers that they are getting involved in time and frequency technology. The people who are concerned with time and frequency services and the people who are concerned with systems that use time and frequency do not seem to know each other as well as they should. In recognition of this gap, the need for this special issue was perceived; its purpose is to promote communication among those with needs and those with resources for providing time and frequency.

The challenge of preparing a Special Issue offered an unusual opportunity to selectively increase communication. On the one hand, authors were chosen to give broad coverage to the time and frequency community with emphasis on dissemination and applications. But in some cases, we consciously sought contributors and reviewers who might influence workers in their disciplines, and who themselves might be influenced by the ideas they considered while participating in this Special Issue. Workers in the fields of communication, navigation, geodesy, long-baseline interferometry, and related areas were invited to meet with workers in time and frequency at Vail, Colo., during the summer of 1971. At that meeting, the entire Special Issue was considered in first draft

form. As would be expected, the need for the addition of some subjects and the deletion of others was identified. It was determined to provide a section of invited letters to allow for the inclusion of late experimental results, short reports, and dissenting opinion.

We have divided the papers in the Table of Contents into five sections: in the first, we have two papers concerned with some international aspects of time and frequency, especially coordination and implications for developing countries. In the second, there is an overview of the generation of frequency and time. The third and fourth sections include interrelated papers describing both the dissemination as well as applications and requirements of time and frequency; e.g., existing or proposed systems such as television or collision avoidance systems can provide dissemination functions and also show stringent time-frequency requirements. Section III emphasizes the dissemination aspect, however, and Section IV concentrates on requirements and applications of time and frequency. The final section contains two papers concerned with some scientific uses of time; one describes opportunities for using long-baseline interferometry for precise time dissemination, and the other addresses geodesy timing requirements.

The reader will find also in the Letters section some communications describing recent developments in the time-frequency field. These cover such subjects as infrared frequency synthesis in metrology, unified frequency-time-length standards, time transfer via pulsar radiations, TV time dissemination, automatic vehicular monitoring (AVM), and the status of a developing country's time and frequency installation, among others.

As an aid to readers we have included a Key Word Index and an Abbreviations List following the papers. The former will guide readers to the location of discussions on particular topics in the

time and frequency papers. The abbreviations generally are common but have not been approved as to usage by authoritative bodies, such as CCIR.

As an examination of the references listed in the papers will indicate, continuing coverage of a subject as broad as the generation, dissemination, and applications of time and frequency will be found in a variety of publications. Within the Institute, the primary source is the IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT, although other IEEE journals and conference records from time to time cover aspects of the subject, particularly from the applications standpoint.

One of the Editors' goals in assembling this issue was to produce a snapshot of the time and frequency technology that would be useful to a great many people; some might have something new to offer, while others might receive information from, the organized time and frequency community. Hopefully, this issue may motivate designers of systems requiring time and frequency to take better advantage of time and frequency services as disseminated, either by standard broadcast stations or services incidental to existing communication or navigation systems. It might encourage some designer to arrange a format for his own internal dissemination scheme so that others, external to his system, may make better use of it. As we look to the future, we trust that our goals will be realized, resulting in effective, direct, and economic time-frequency dissemination with significant conservation of frequency spectrum.

JAMES L. JESPERSEN, *Guest Editor*  
 BYRON E. BLAIR, *Associate Guest Editor*  
 LAWRENCE E. GATTERER, *Associate Guest Editor*

#### ACKNOWLEDGMENT

This issue could not have existed without the help and cooperation of a great many people. I particularly wish to express my appreciation to J. A. Barnes, R. E. Beehler, D. Halford, R. L. Fey, D. W. Hanson, and G. Kamas of the National Bureau of Standards, Time and Frequency Division, Boulder, Colo.; to R. Grubb of the National Oceanic and Atmospheric Administration, Space Environment Laboratory, Boulder, Colo.; to L. N. Bodily of the Hewlett-Packard Co., Santa Clara, Calif.; and to A. D. Watt of the Westinghouse Co., Boulder, Colo., for their contributions to and in-depth reviews of many of the papers in this issue. Much of the success of the authors' meeting at Vail, Colo., is due to Sandra Danielson and J. Kluge, of the National

Bureau of Standards, Boulder, Colo., and J. Rose, of Communications Management Co., Palos Verdes Estates, Calif. The United States Air Force Communications Service, Richards-Gebaur Air Force Base, provided financial support to portions of the information gathering activities of the Guest Editors. I owe a special debt of gratitude to my two Associate Editors who have contributed extensively to every phase of this issue. My final thanks, of course, go to the authors whose papers make up the backbone of this issue.

JAMES L. JESPERSEN  
*Guest Editor*



**James L. Jespersen (SM'71)** received the B.A. and M.S. degrees in physics in 1956 and 1961, respectively, from the University of Colorado, Boulder.

In 1956 he joined the Radio Propagation Physics Division of the National Bureau of Standards, where he worked in the areas of radio astronomy, ionospheric research, and radio propagation. In 1962-1963 he was a Visiting Scientist at the Radio Research Laboratory, Slough, England, where he was engaged in theoretical investigations of the propagation of very-low-frequency radio waves. He is presently Chief of the Frequency-Time Dissemination Research Section of the Time and Frequency Division.

Mr. Jespersen is a member of the Scientific Research Society of America, Sigma Pi Sigma, IRIG, and Study Group 7 of the International Radio Consultative Committee (CCIR).



**Byron E. Blair (M'62-SM'70)** received the B.S. degree in physics from Wheaton College, Wheaton Ill., in 1942.

During World War II he was on active duty as an Officer in the U. S. Navy and is now a retired Lieutenant Commander in the U. S. Naval Reserve. Later he was associated with the U. S. Bureau of Mines, College Park, Md., where he evaluated vibration instrumentation and studied varied aspects of rock mechanics. In 1960 he joined the National Bureau of Standards, and he is now with the Time and Frequency Division, where he is engaged in research on precise frequency measurement and phase stability of radio signals. He has contributed several papers to Radio Science and is co-editor of NBS Special Publication 300, vol. 5 (Precision Measurement and Calibration—Frequency and Time). In August 1969, he served as a National Academy of Sciences-National Research Council delegate to the 16th General Assembly of URSI in Ottawa, Canada.

Mr. Blair is a member of Study Group 7 of the International Radio Consultative Committee (CCIR) and of the Scientific Research Society of America.



**Lawrence E. Gatterer (M'56-SM'72)** received the B.S. degree in engineering physics in 1956 and the M.S. degree in electrical engineering in 1961, both from the University of Colorado, Boulder.

He joined the National Bureau of Standards, Boulder, in 1956 working first in the Central Radio Propagation Laboratory, later in the Radio Standards Physics Division, and presently in the Time and Frequency Division. In addition he has been an Instructor of Electrical Engineering at the University of Colorado. His publications are in the fields of instrumentation and time and frequency dissemination research. He spent 1969-1970 in Washington, D. C., as a participant in the Department of Commerce Science and Technology Fellowship Program. His assignment was Assistant to the Director, Office of Telecommunication.

Mr. Gatterer is a member of the Scientific Research Society of America, the IEEE Instrumentation and Measurements Group, and Study Group 7 of the International Radio Consultative Committee (CCIR). He is a member of the Conference Committee of the 1972 Conference on Precision Electromagnetic Measurements.