

Specification of the Transmitted Signal of the U.S. Marine Radiobeacon System

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January 1983
Final Report

This document is available to the public
through the National Technical Information
Service, Springfield, Virginia 22161.

U.S. Department
of Transportation
**United States
Coast Guard**



Office of Navigation
Washington DC 20593

1. Report No. DOT-CG-N-2-82		2. Government Accession No.		3. Recipient's Catalog No.	
4. Title and Subtitle Specification of the Transmitted Signal of the U.S. Marine Radiobeacon System			5. Report Date January 1983		
			6. Performing Organization Code TSC/DTS-52		
7. Author(s) Arthur E. O'Brien			8. Performing Organization Report No. DOT-TSC-CG-82-6		
9. Performing Organization Name and Address U.S. Department of Transportation Research and Special Programs Administration Transportation Systems Center Cambridge, MA 02142			10. Work Unit No. (TRAIS) CG235/2009		
			11. Contract or Grant No.		
12. Sponsoring Agency Name and Address U.S. Department of Transportation U.S. Coast Guard Office of Navigation Washington, DC 20593			13. Type of Report and Period Covered Jan.-Nov. 1982 Final Report		
			14. Sponsoring Agency Code G-NRN-2		
15. Supplementary Notes					
16. Abstract This report documents the specification of the transmitted signal of the U.S. Marine Radiobeacon System. It is intended as a reference document consisting of specifications, definitions, and explanations for general use by designers, manufacturers, and users of this system.					
17. Key Words Marine Radiobeacon, Radionavigation, Signal Specification			18. Distribution Statement DOCUMENT IS AVAILABLE TO THE U.S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE, SPRINGFIELD, VIRGINIA 22161		
19. Security Classif. (of this report) UNCLASSIFIED		20. Security Classif. (of this page) UNCLASSIFIED		21. No. of Pages 17	22. Price

PREFACE

In July 1981, a set of signal specifications was published for the LORAN-C radionavigation system. The development of these specifications was restricted to the characteristics of the LORAN-C signal at the transmitter; however certain characteristics of the overall system were considered. The experience gained in the development of the LORAN-C signal specifications identified the need for a similar set of specifications for the U.S. Marine Radiobeacon System. Those specifications are reported herein.

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1.0 INTRODUCTION

The U.S. Marine Radiobeacon System is a key element in both the Department of Transportation (DOT) and the Department of Defense (DOD) plans for navigation. This system is operated and maintained by the U.S. Coast Guard to provide accurate radionavigation service to users in the coastal navigation zones of the United States and in the Great Lakes. This specification defines the services provided in terms of the transmitted signal.

1.1 PURPOSE

This specification provides a technical description of the U.S. Marine Radiobeacon System signal at the transmitting stations. It is intended as a reference document consisting of specifications, definitions, and explanations for general distribution to designers, manufacturers, and users of this system.

1.2 SCOPE

This specification is restricted to the operational transmitted signal; however, other aspects of the system are discussed for information purposes. Section 2.0 provides general background information on the Radiobeacon System. The transmitted signal specification is presented in Section 3.0. Parameters that affect system usage are discussed in Section 4.0 and relevant definitions are given in Section 5.0.

2.0 RADIOBEACON INFORMATION

Basic descriptions and explanations of the U.S. Marine Radiobeacon System and its elements and characteristics are presented here as introductory material prior to the definition of the transmitted signal specification itself. That specification is defined in Section 3.0.

2.1 OVERVIEW

The U.S. Marine Radiobeacon System is an aid to navigation operated by the U.S. Coast Guard under the authority of Title 14 USC 81 (1). Each radiobeacon transmits a distinctive continuous carrier, keyed tone, radio signal at an assigned frequency in the band 285-325 kHz. These signals enable mariners to take bearings by means of shipboard radio direction finders. Such bearings are generally accurate to two degrees or less, depending on the equipment used and the skill of the operator.

Short range radiobeacons, nominally 10 nautical miles (NM) in range, are located in harbors, in waterways, and at harbor entrances. Radiobeacons of intermediate range, nominally 50 NM in range, constitute the majority of the system and are located to meet the requirements for harbor approach and for coastal and Great Lakes navigation. Longer range radiobeacons, 100 NM or more in range, are installed at a few widely separated locations of strategic importance to navigation, such as at significant landfalls. The Radiobeacon System is configured such that a vessel engaged in coastal navigation about the United States or on the Great Lakes will always be within range of at least one and most probably two or more radiobeacons. Geographic locations of Marine Radiobeacons and their assigned characteristics, operating frequencies, and service ranges may be obtained from the following sources:

the six one-minute periods. A continuous radiobeacon operates continually, every minute of every hour, not sharing its radio frequency with any other station within its operating range.

Special calibration radiobeacons of short range capability broadcast in clear weather to enable vessels to swing ship for the purpose of calibrating their radio direction finders. These calibration stations operate only on advance request to the Commander of the Coast Guard District in which the calibration station is located.

Further information concerning the operational characteristics of individual radiobeacons may be obtained from the Coast Guard Light Lists.

2.4 ADVERTISED SERVICE RANGE

The advertised service range of a radiobeacon is the range at which it will provide a prescribed field intensity level to the user. The prescribed field intensities for U.S. Marine Radiobeacon signals, established by international agreement, are as follows:

- 50 microvolts per meter for radiobeacons north of 40°N
- 75 microvolts per meter for radiobeacons between 40°N and 31°N
- 100 microvolts per meter for radiobeacons south of 31°N

2.5 PROTECTION RATIO

Service provided by radiobeacons must be protected from intrasystem interference. This has been achieved by designing and operating the system such that, for any radiobeacon considered, the signal intensity at its advertised range will be stronger than those from other radiobeacons. The difference between desired and undesired signal strengths, expressed as a ratio in decibels (dB) is known as the "protection ratio". The system is operated to ensure a protection ratio of 15 dB for sequenced and continuous radiobeacons, 22 dB for calibration radiobeacons, and 28 dB with respect to Canadian radiobeacons.

2.6 CALIBRATION

Radiobeacons are calibrated upon establishment. Field strength measurements are conducted and appropriate adjustments are made to the beacon equipment periodically on a routine basis. Radiobeacons are re-calibrated whenever there are major alterations to radiobeacon equipment or to surrounding structures or when there is data to indicate the existance of deviations from the desired transmitted signal.

2.7 FAILURE MODES

The low power transmitter (CDWQ-NX 250 BD, 62.5 Watts) uses a single power amplifier to provide the required signal. A redundant amplifier and duplicate keyers are provided within that transmitter. Provision has been made for automatic switching between duplicated equipment to ensure continuity of service in the case of failure or malfunction.

The medium and high power transmitters (CDWQ-NX 1000 BD, 250 Watts and CDWQ-NW 4000 BD, 1000 Watts) also contain dual keyers and use ganged low

TABLE I

SUMMARY OF RADIOBEACON SIGNAL SPECIFICATIONS

FREQUENCY BAND	285-325 kHz
FREQUENCY CONTROL	CRYSTAL
FREQUENCY TOLERANCE	± 0.01% of assigned frequency
TYPE OF EMISSION	Type H2A (tone modulated CW)
MODULATION	TYPE: keyed upper sideband separated from carrier by 1020 Hz LEVEL: 70% ± 5%
SPURIOUS EMISSIONS	As low as practicable compliant with FCC Rules and Regulations Parts 81 and 87
CODE CONTENT	1, 2, or 3 International Morse characters
CHARACTERISTIC KEYING	
Rate	10 words/minute, nominal
Dot Element Length	0.125 seconds
Dash Element Length	0.375 seconds
Interval between Elements	0.125 seconds
Interval between Characters	0.375 seconds
Interval between Characteristics	0.625 seconds
OPERATING CYCLE	50 second coded period followed by a 10 second dash
MODE OF OPERATION	Continuous - operating cycle repeated every minute Sequenced - operating cycle repeated one minute out of each 6 minute period for a six beacon grouping Calibration - continuous upon advance notice
SIGNAL STRENGTH AT ADVERTISED RANGE	50 microvolts/meter north of 40°N 75 microvolts/meter between 40°N and 31°N 100 microvolts/meter south of 31°N
GEOGRAPHIC COVERAGE	Coastal navigation zones and Great Lakes

3.6 SIGNAL STRENGTH

Each radiobeacon shall provide a prescribed signal level at the limits of its advertised service range. The prescribed field intensities for the U.S. Marine Radiobeacon System are:

- 50 microvolts per meter for radiobeacons north of 40°N
- 75 microvolts per meter for radiobeacons between 40°N and 31°N
- 100 microvolts per meter for radiobeacons south of 31°N

3.6.1 Field Intensity Requirements

The field intensity levels specified in Table II shall be provided to ensure that the proper radiobeacon signal level is available at the limit of the advertised service range.

3.6.2 Protection Ratio

The protection ratio for continuous and sequenced radiobeacons shall be 15 dB except for Canadian stations which under international agreement are afforded 28 dB protection. The protection ratio for calibration radiobeacons shall be 22 dB.

3.7 GEOGRAPHIC COVERAGE

The U.S. Marine Radiobeacon System shall be so configured that a vessel engaged in coastal navigation or in the Great Lakes will always be within range of at least one and preferably two or more radiobeacon signals.

3.8 CONFORMANCE

All U.S. Marine Radiobeacons shall be calibrated upon establishment. Field strength measurements shall be conducted periodically thereafter on a routine basis to ensure conformance to the specification presented herein. Radiobeacons shall be re-calibrated whenever there are major alterations to radiobeacon equipment or to surrounding structures or when there is data to indicate deviations from these specifications.

4.0 USER CONSIDERATIONS

Some of the more pertinent factors which should be considered by the users of the U.S. Marine Radiobeacons Systems are discussed briefly in this section.

4.1 VESSEL INDUCED ERROR

The direction of travel of a radio wave is changed as it passes through electromagnetic fields. Such fields exist in the presence of metallic objects. Many vessels exhibit certain electromagnetic field characteristics because they are constructed of metal and most employ rigging, masts, and other items of a metallic nature. The radio direction finder antenna should be located as clear of these fields as possible. Unfortunately, all the electromagnetic influences of a vessel cannot be avoided. Therefore, the mariner must somehow consider them when taking radio bearings. The most effective way to accomplish this is to calibrate the radio direction finder after installation and to verify its accuracy from time to time, and especially whenever structural changes to a vessel occur.

In order to facilitate radio direction finder calibration, the Coast Guard operates and maintains calibration stations which provide their services on special request. Calibration is accomplished by comparing visual bearings to radio bearings, recording the difference and preparing a calibration curve. This curve should be posted so that the navigator can conveniently apply corrections to radio bearings.

4.2 MERCATOR ERROR

The signal transmitted by a radiobeacon follows a great circle course. Radio bearings may be plotted directly on a Mercator chart if the distance to the beacon is less than 50 NM or if the distance in longitude involved is not in excess of two degrees. When these measures are exceeded a correction should be applied. Corrections are published in Defense Mapping Agency Hydrographic/Topographic Center Publication 117, Radionavigational Aids.

4.3 FIX

A bearing from a radiobeacon may be combined with bearing information from other radiobeacons or from other sources, such as a line of position from an astronomical or LORAN observation, to locate (fix) the position of the vessel.

The position of a vessel may be estimated from radio bearings on a single radiobeacon by taking successive bearings on the station with intervening periods of time and plotting these with respect to the distance and course run between the times the bearings are taken. Though a position so obtained is often referred to as a "running fix" it is not a fix and should be used with caution.

4.4 HOMING

A radiobeacon may be used as a leading mark for which to steer directly. The navigator can correct the course from time to time using successive radio bearings. Such a signal off a harbor entrance or other objective may be approached with certainty from a considerable distance. Following a signal to its source is referred to as "homing". This procedure should be practiced with caution. The navigator must be sure that the origin of the signal is of sufficient distance to avoid grounding or collision.

4.5 RECIPROCAL BEARINGS

It is of extreme importance to avoid the use of reciprocal bearings (180° ambiguity). The mariner homing on a reciprocal bearing may be far at sea before discovering this error. Likewise, a radiobeacon fix obtained by using reciprocal bearings would provide false position information. The false position may indicate that the mariner is in safe waters while in fact an extremely hazardous situation may exist.

Ambiguity may be avoided when using a radio direction finder without a sense antenna by taking repeated radio bearings and observing the direction in which they tend to change. If the vessel is making forward way, successive bearings will move aft on the side of the vessel on which the radiobeacon lies.

Sequenced Mode: code cycle information provided during the appropriate period of the sequenced cycle. Sequence cycle is repeated continuously.

Service Range: see advertised service range.

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