

RECOMMENDATION ITU-R M.589-3*

Technical characteristics of methods of data transmission and interference protection for radionavigation services in the frequency bands between 70 and 130 kHz

(1982-1986-1992-2001)

The ITU Radiocommunication Assembly,

considering

- a) that radionavigation systems exist or are being implemented in the three Regions of the ITU;
- b) that various services, including radionavigation systems, operate in frequency bands between 70 and 130 kHz;
- c) that the operating characteristics of these radionavigation systems are well established and sufficiently documented by the appropriate service providers;
- d) that radionavigation being a safety service, all practical means consistent with the Radio Regulations (RR) should be taken to prevent harmful interference to any radionavigation system;
- e) that users of phased pulsed radionavigation systems in the band 90-110 kHz receive no protection outside that band, yet may receive benefit from their signals outside the occupied bandwidth;
- f) that in the band 90-110 kHz, different phased pulsed radionavigation systems may operate in adjacent areas, on the same assigned frequency and within the same occupied bandwidth;
- g) that Loran-C and Chayka systems are characterized by ground waves that follow the Earth's contours with ranges that exceed comparably powered medium frequency systems, and by sky waves that may be received at considerably greater distances;
- h) that Loran-C or Chayka systems provide an independent radionavigation system to complement the global navigation satellite system (GNSS);
- j) that GNSS components exist or are being implemented and the accuracy may not be enough for some specialized navigation, or for the position sensor in electronic chart systems;
- k) that safety applications require integrity information for position fixes derived from GNSS;
- l) that the accuracy and integrity of GNSS can be improved considerably by the transmission of differential corrections or other data;

* This Recommendation should be brought to the attention of the International Maritime Organization (IMO), the International Civil Aviation Organization (ICAO), the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA) and Radiocommunication Study Group 7.

- m) that appropriate modulation of Loran-C and Chayka transmissions enables these systems to transmit differential GNSS corrections, integrity messages and other data without interfering with the Loran-C or Chayka navigation function;
- n) that the transmission of differential GNSS corrections, integrity messages and other data may benefit from the long-range transmission characteristics of Loran-C or Chayka;
- o) that appropriate modulation of Loran-C and Chayka transmissions increases the efficiency of the use of the available bandwidth;
- p) that a number of administrations currently provide Loran-C or Chayka coverage of coastal waters and land areas enabling a worldwide standard for the transmission of differential GNSS corrections, integrity messages and other data to be introduced efficiently and economically;
- q) that other methods of data transmission using Loran-C or Chayka signals may be introduced,

recommends

- 1 that information be exchanged between the authorities operating radionavigation systems in the band 90-110 kHz with those operating other systems in the band 70-130 kHz employing stable transmissions;
- 2 that administrations operating radionavigation systems in the band 90-110 kHz in adjacent areas coordinate the technical characteristics of their individual systems in accordance with the RR;
- 3 that within the allocated band 90-110 kHz, the protection criteria for pulsed radionavigation systems (e.g. Loran-C and Chayka) should be in terms of unwanted to wanted emissions and in accordance with Annex 1;
- 4 that determination of Loran-C signal levels should be in accordance with the guidelines given in Annex 1;
- 5 that any method of data transmission using Loran-C and Chayka signals should preserve the utility of the existing radionavigation services;
- 6 that a data service using tri-state pulse position modulation of Loran-C or Chayka signals should be designed in accordance with the technical characteristics given in Annex 2.

ANNEX 1

Loran-C/Chayka protection criteria and signal level determination guidelines

1 Protection criteria

1.1 The protection criteria for Loran-C/CW interference as a function of frequency offset are given in Fig. 1.

1.2 Near-synchronous interference at frequency, f , should satisfy the following relationship:

$$\left| f - \frac{n}{2 GRI} \right| < f_b$$

where:

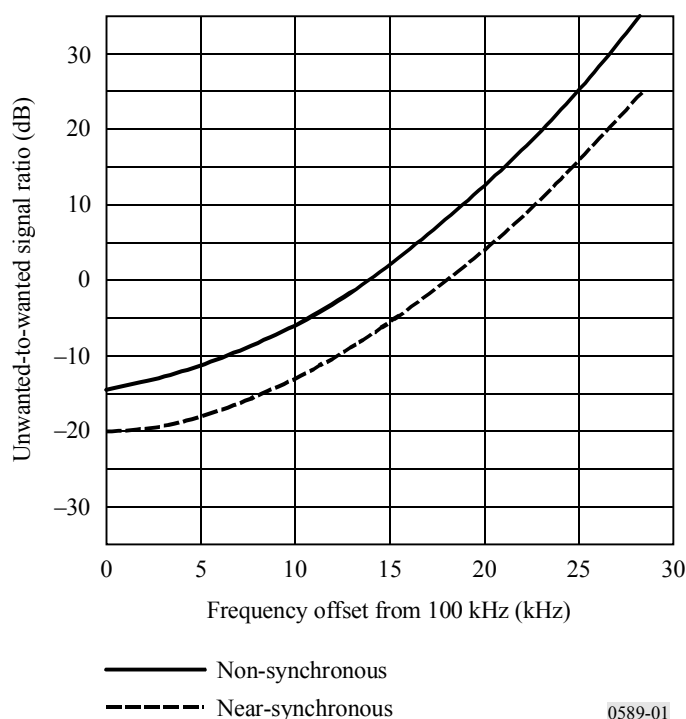
GRI : group repetition intervals

n : any integer, and

f_b : response bandwidth of the receiver (related to response time).

In the track-mode, typical Loran-C receivers have a -3 dB tracking response of 0.01 Hz for marine receivers and 0.1 Hz for aeronautical receivers. However, in the signal acquisition, or search mode, the response may be of considerably higher frequency. The value of $f_b = 1.0$ Hz is therefore recommended to be used.

FIGURE 1
Loran-C/CWI protection criteria



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1.3 The protection criteria for Loran-C/FSK interference as a function of frequency offset are given in Fig. 2.

2 Signal level determination guidelines

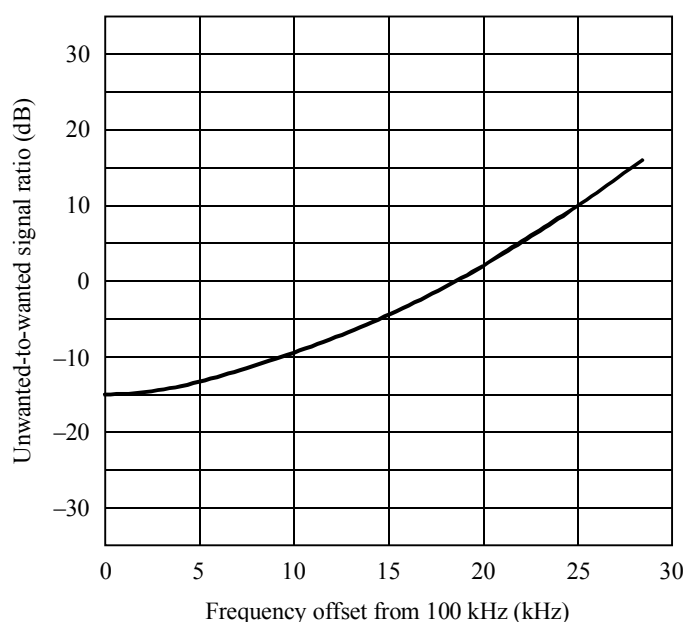
The application of Figs. 1 and 2 to determine a maximum acceptable field strength of a specific unwanted signal to a known frequency requires knowledge of the expected Loran-C signal strength. This expected signal strength varies widely within the coverage area of a specific Loran-C chain. However, a minimum level may be determined at the coverage boundary.

The area of Loran-C coverage is specified by the administration operating the stations within a chain. This chain coverage area is determined on the basis of the Loran-C signal strength with respect to expected ambient noise levels. The S/N at the boundary of the coverage area is typically -10 dB. Therefore, the S/N within the defined coverage area is greater than that value. The ambient noise levels used to calculate the boundaries are derived from Recommendation ITU-R P.372 – Radio noise. The Loran-C field strength, measured at the boundary of that coverage

area, then represents the minimum expected. For example, if the expected noise level is 55 dB(μ V/m), a Loran-C signal level of 45 dB(μ V/m) or higher would likely be found throughout the coverage area. 45 dB(μ V/m) could then be used as the value of the wanted signal in conjunction with Figs. 1 and 2.

A study relative to chains operated within the United States of America reported that Loran-C signal levels within defined coverage areas may be as low as 43 dB(μ V/m). Using this value, and considering a near-synchronous CWI signal between 90 and 110 kHz, the maximum unwanted-to-wanted signal level, determined from Fig. 1 is –20 dB. In this case, the unwanted field strength at the Loran-C receiver may have to be below 23 dB(μ V/m) to prevent interference.

FIGURE 2
Loran-C/FSK protection criteria



0589-02

ANNEX 2

Technical characteristics of a tri-state pulse position modulation (3s-PPM) data service using Loran-C and Chayka transmissions in the frequency band 90-110 kHz

1 Structure

The structure given in Table 1 is used for signal specification.

TABLE 1

Structure for signal specification

1	Physical layer	Loran-C and Chayka signal specification	As documented by the appropriate service providers
2	Modulation/demodulation layer	Description of the 3s-PPM	§ 2 of this Annex
3	Forward error correction (FEC) layer	Description of the FEC algorithm	§ 3 of this Annex
4	Message coding layer	Description of the message coding algorithm	§ 4 of this Annex

2 Modulation/demodulation layer

These definitions give the modulation of the Loran-C or the Chayka signal to enable data transmissions. The definitions include the low level modulation type, the modulation strategy to minimize devaluation of Loran-C or Chayka use for positioning and the relation between modulation patterns and other data representations.

2.1 Pulse modulation

2.1.1 Timing

A 3s-PPM should be applied to pulses three (3) to eight (8) of each pulse group. The modulation should consist of a time-shift of one (1) μs of the pulse transmission, with respect to an unmodulated pulse. The three possible states of the modulation are given in Table 2.

TABLE 2

States of the modulation

Pulse state	Transmission time minus time of reference pulse (μs)	Indication
Advanced pulse	−1	−
Prompt pulse	0	0
Delayed pulse	+1	+

2.1.2 Modulation balance

The number of advanced and delayed pulses of one channel in one pulse group should be equal. The modulation of six (6) pulses in one pulse group results in 141 possible balanced patterns, refer to Table 3, of which 128 patterns should represent valid data, one (1) pattern should indicate no data transmission and 12 patterns should be not used.