NATO STANDARD

AComP-4205

TECHNICAL STANDARDS FOR SINGLE CHANNEL UHF RADIO EQUIPMENT

Edition A Version 1

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NATO LETTER OF PROMULGATION

22 February 2018

1. The enclosed Allied Communications Publication AComP-4205, Edition A, Version 1, TECHNICAL STANDARDS FOR SINGLE CHANNEL UHF RADIO EQUIPMENT, which has been approved by the nations in the Consultation, Command, and Control Board (C3B), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4205.

2. AComP-4205, Edition A, Version 1, is effective upon.

4. This publication shall be handled in accordance with C-M(2002)60.

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
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RECORD OF SPECIFIC RESERVATIONS

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Related Documents:

STANAG 4202	-	Transmission Envelope Characteristics for High Reliability Delta Exchange between Land Tactical Data Processing Equipment over Single Channel Radio Links
STANAG 5510	-	Maritime Tactical Data exchange - Link 10
STANAG 5511	-	Tactical Data Exchange - Link 11
STANAG 5514	-	Tactical Data Broadcasting - Link 14
STANAG 5522	-	Tactical Data Link – Link 22
STANAG 4691	-	Multi-Hop IP Networking with Legacy UHF Radios: Maritime Line of Sight Networking (MARLIN)
ACP-167(J)	-	Glossary of Communication Electronics Terms

AIM

1. The aim of this agreement is to define the technical standards required to ensure interoperability of land, air and maritime single channel UHF radio equipment.

AGREEMENT

2. Participating nations agree to use the standards defined in this STANAG for the traffic mode or modes in which interoperability is required.

GENERAL

3. The terms and definitions are detailed in Annex A. The basic technical standards are in Annex B. Other Annexes contain enhanced technical standards for the operation of complex waveforms.

IMPLEMENTATION OF THE AGREEMENT

4. This STANAG is implemented by a nation when the single channel UHF radio equipment in that nation's forces comply with the characteristics described in this STANAG and are placed in service.

ANNEX A TERMS AND DEFINITIONS

BANDWIDTH, OCCUPIED (See also ACP-167)

1. The width of a frequency band such that, below the lower and above the upper frequency limits, the mean powers emitted are each equal to a specified percentage of B/2 of the total mean power of a given emission. Unless otherwise specified, the value of B/2 should be taken as 0.5%.

BASEBAND

2. In the process of modulation, the frequency band occupied by the aggregate of the transmitted signals when first used to modulate a carrier.

CARRIER (See also ACP-167)

3. An electromagnetic wave suitable for modulation by the intelligence to be transmitted over a communication system.

FREQUENCY, ASSIGNED (See also ACF-167)

4. The center of the frequency band assigned to a station.

FREQUENCY, TOLERANCE (See also ACF-167)

5. The maximum permissible departure by the center frequency of the frequency band occupied by an emission from the assigned frequency, or by the characteristic frequency of an emission from the reference frequency.

MODULATION (See also ACP-167)

6. The process of varying some characteristics of the carrier wave in accordance with the instantaneous value of samples of the intelligence to be transmitted. See CARRIER.

MODULATION, AMPLITUDE (AM) (See also ACP-167)

7. The form of modulation in which the amplitude of the carrier varies in accordance with the instantaneous value of the modulation signal.

MODULATION, FREQUENCY (FM) (See also ACP-167)

8. The form of modulation in which the instantaneous frequency of a sine wave carrier is caused to depart from the carrier frequency by an amount proportional to the instantaneous value of the modulating signal.

RETRANSMISSION (REBROADCAST) (See also ACP-167)

9. The repetition of a net radio transmission through a radio repeater station. (Usually accomplished by interconnecting two net radios so that a signal received by one is retransmitted by the other).

RATT (See also ACP-167) **and MORSE**

10. RATT is the system of communication by teletypewriter over radio circuits. MORSE is the method of transmitting text information as a series of on – off tones. A tone modulation using audio tones is used. The tone modulation can be performed via an external modem.

SIGNAL, ANALOG

11. A nominally continuous electrical signal that varies in some direct relationship with the instantaneous value of samples of the intelligence to be transmitted.

SIGNAL, DIGITAL

12. A nominally discontinuous electrical signal that changes from one state to another in discrete steps in some direct relationship with the instantaneous value of samples of the intelligence to be transmitted

SQUELCH (See also ACP-167)

13. A term indicting the ability of a radio receiver to prevent an audio frequency output in the absence of an input signal having predetermined characteristics.

RECEIVER ATTACK-TIME

14. The time interval from the application of a step input RF signal (for all signal levels within the receiver input range) to the receiver input until the receiver output amplitude reaches 90 per cent of its steady-state value. This time delay includes the time for the receiver to un-squelch, if applicable.

RECEIVER RELEASE-TIME

15. The time interval from removal of RF energy at the receiver input until the receiver output falls to 10% of its steady value, or until the receiver output is squelched if applicable.

TRANSMITTER ATTACK-TIME

16. The time interval from keying-on a transmitter until the transmitted RF signal amplitude has increased to 90 per cent of its steady-state value. This delay excludes any necessary time for automatic antenna tuning.

TRANSMITTER RELEASE-TIME

17. The time interval for keying-off a transmitter until the transmitted RF signal amplitude has decreased to 10 per cent of its key-on steady-state value.

TRANSMISSION, AMPLITUDE SIDEBAND (See also ACP-167)

18. When a carrier frequency is amplitude modulated by a modulating signal, the band of frequencies produced on either side of the carrier frequency include components whose frequencies are, respectively, the sum or difference of the carrier and the modulating frequencies. The sum frequencies form the "upper side-band" and the difference frequencies form the "lower side-band".

TRANSMISSION DOUBLE SIDEBAND (See also ACP-167)

19. In double sideband transmission both the upper and lower sidebands are transmitted without reduction or suppression.

OFF-SET CARRIER OPERATION

20. The procedure in which multiple (2, 3 or 4) transmitters are used to cover an extended air traffic control area by operating on the same nominal channel but with carrier frequencies off-set by 0, 2.5, 5 or 7.5 kHz to allow the simultaneous reception of multiple signals without intrusive audio tones.

ANNEX B TECHNICAL STANDARDS TO ENSURE INTEROPERABILITY OF SINGLE CHANNEL UHF RADIO EQUIPMENT

FREQUENCY RANGE

1. The frequency range shall be from 225MHz to 399.975MHz.

TUNING

2. Equipment shall tune to integral multiples of 25kHz starting at 225MHz.

FREQUENCY ACCURACY

3. (a) The radio frequency accuracy, including tolerance and long-term stability but not any effects due to doppler shift, shall be within +/- 2kHz.

(b) In offset carrier operation, the frequency of any offset carrier shall be within +/- 8kHz of the assigned frequency.

FREQUENCY RESPONSE

4. (a) For analogue voice and inband RATT the baseband frequency response of the transmitter and of the receiver over the rage 300Hz to 3400Hz shall be within +/-4dB of the response at 1000Hz for manpack equipment and within +/-2dB for all other equipment.

(b) For digital voice/data at 16kbps in the form of a polar non-return-to-zero signal (see CCITT V10, V11, V28) at least one of the following interfaces shall be supported:

, (b1) Analogue baseband interface: The baseband frequency response of the transmitter and of the receiver over the range 20Hz to 11kHz shall be within +/-3dB of the response at 1000Hz.

(b2) Digital baseband interface: It is recommended that the frequency response is optimized for Binary Non-Return-to-Zero (NRZ) signals. Analogue measurements do not apply to digital wideband modes.

(c) The recommended receiver IF selectivity characteristics are:

not less than +/-11kHz at -5dB
not more than +/-25kHz at -60dB
not more than +/-1MHz at -100dB

MODULATION

5. (a) For analogue voice and for inband RATT in the form of two-tone FSK, the carrier shall be double-sideband amplitude modulated, with a peak modulation index of not less than 0.85.

(b) For digital voice/data at 16 kbps, the primary carrier modulation method for interoperability shall be the same as for analogue voice and inband RATT but it is desirable that the equipment include also a capability for frequency modulation with, as an interim standard, a peak deviation of 5.5 kHz +/-1kHz. For Link 22 Tactical Data Transmission, the technical specification in Annex C shall apply.

(c) Single channel RATT shall be sent by two-tone FSK with a mark (or 1) frequency of 500Hz +/- 4Hz and a space (or o) frequency of 700Hz +/- 4Hz.

(d) Morse telegraphy shall be sent by on-off keying of a 1000Hz +/-5Hz tone at rates up to 30wpm (manual) and 300wpm (burst).

OCCUPIED BANDWIDTH

6. (a) 99% of the total mean radiated power shall be contained within a bandwidth of 25kHz; the power of any spurious emission shall be at least 40dB below the peak envelope power within +/-100kHz of the carrier frequency and at least 60dB below the peak envelope power at any other frequency.

(b) For frequency modulation 94% of the total mean radiated power shall be contained within a bandwidth of 25kHz; the power of any spurious emission shall be at least 40dB below the peak envelope power within +/-100kHz of the carrier frequency and at least 60dB below the peak envelope power at any other frequency.

MODE OF OPERATION

7. Equipment shall be capable of operating in the single-frequency simplex mode.

SWITCHING TIME

8. (a) Transmitter attack time shall not be more than 25ms and release time not more than 10ms.

(b) Receiver attack time shall not be more than 40ms and release time not more than 60ms.

SQUELCH AND RE-TRANSMISSION (optional)

9. (a) Receiver squelch action shall not depend on the addition of special characteristics to the transmitted signal.

(b) The receiver squelch circuit shall be able to control the switching of another radio for re-transmission.

(c) The squelch circuit threshold shall not degrade by more than 3dB for RF signals as defined by STANAG 3281 (Personal Locator Beacon) and ICAO documents.

(d) The squelch attack time shall not be more than 50ms.

(e) When used for the reception of air traffic control transmissions onboard airborne platforms, receiver squelch action should not be suppressed by the presence of multiple off-set carrier signals. It is recommended that the squelch functionality should allow a minimum multi-carrier sensitivity of -90 dBm defined as the combined RF carrier level of a multi-carrier input signal (for 2, 3 and 4-leg offset carrier operation, equates to individual carriers at -96 dBm in a 4-leg scenario).

AERIAL POLARIZATION

10. For shipborne and airborne operation the radiated field shall be vertically polarized.

GUARD RECEIVER (optional)

11. (a) The guard receiver shall be permanently tuned to a frequency of 243MHz +/-2.5kHz and shall accept double-sideband amplitude modulated signals from a transmitter having a radio frequency inaccuracy of up to +/-12kHz.

(b) The squelch characteristics of the guard receiver shall be the same as those of the main receiver.

ANNEX C LINK 22 (NILE) - TACTICAL DATA TRANSMISSION IN UHF FIXED-FREQUENCY - 16 kb/s NRZ FM DIGITAL DATA

1. Introduction

This Annex specifies the characteristics of a UHF Fixed-Frequency waveform for operation in NATO Improved Link Eleven (NILE) networks. Specifications given in ANNEX B.

2. Frequency Range

The nominal frequency range for RF carriers shall be from 225 MHz to 399.975 MHz, as specified in STANAG 4205, ANNEX B, paragraph 1.

3. Tuning

Radio frequency carriers shall be tuned to an integral multiple of 25 kHz, starting at 225 MHz, as specified in STANAG 4205, ANNEX B, paragraph 2.

4. Frequency Accuracy

Radio-frequency carrier accuracy, including tolerance and long-term frequency stability but not any effects due to Doppler shift shall be within ±2 ppm.

5. Modulation

The modulation shall consist of a Binary Non-Return-to-Zero (NRZ) digital signal applied to an RF carrier using Frequency Modulation (FM) at a rate of 16,000 bits per second (b/s), producing a peak frequency deviation of 5.5 kHz ± 1 kHz from the RF carrier, as specified in STANAG 4205, ANNEX B, paragraph 5(b) (interim standard). The modulation format encodes the binary digit one ('1') as a frequency deviation of +5.5 kHz ±1 kHz from the RF carrier and encodes the binary digit zero ('0') as a frequency deviation of -5.5 kHz ±1 kHz from the RF carrier.

It is recommended that the baseband frequency response of the transmitter should be optimized for Binary Non-Return-to-Zero (NRZ) signals instead of analog signals as specified in STANAG 4205, ANNEX B, paragraph 4b.

It is recommended that the throughput delay of the transmitter baseband interface is not more than 500µs.

6. Power Spectral Density

The power spectral density of a transmitted signal with random digital data shall comply with the bandwidth occupation requirement, as specified in STANAG 4205, ANNEX B, paragraph 6.

7. Slot Structure

A Time-Division Multiple-Access (TDMA) Slot is the high-level structure in which information shall be transmitted and received in NILE. A TDMA slot is composed of a Transmit Guard (xmt guard), Preamble, one or more Coding Frames, and a Propagation Guard Time, as shown in Fig. 1. The duration of the Preamble plus the duration of the Transmit and Propagation Guard Times shall be equal to the duration of one Coding Frame. The TDMA slot starts with the Transmit Guard.

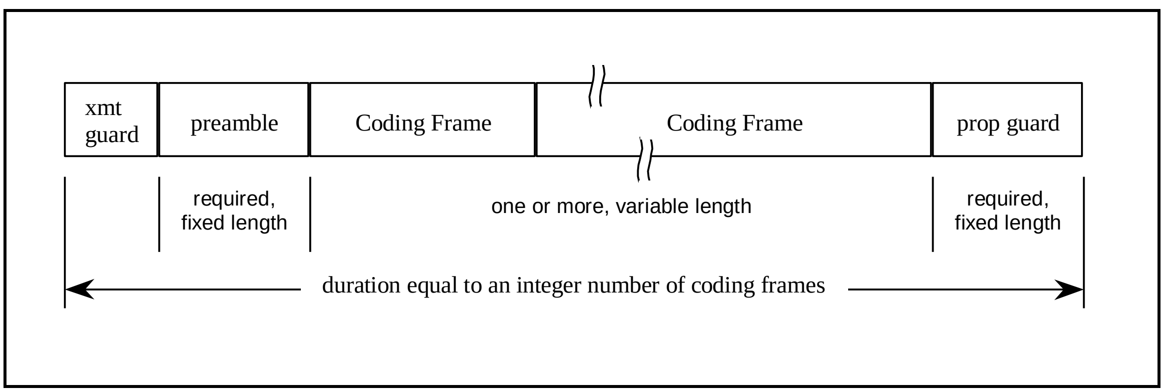

Fig. 1: TDMA Time Slot Structure

7.1 Transmit Guard

The transmit guard duration is 22 msec (corresponding to 352 bits). When transmitting in a slot, the transmitter keyline shall be enabled at the beginning of the transmit guard segment.

7.2 Preamble Structure

(a) The preamble shall consist of 255 binary digits (bits) transmitted in binary NRZ format at a modulation rate of 16 kb/s. The preamble duration is 15.9375 msec.

(b) The preamble shall be the output generated by an eight-stage maximal-length linear shift-register generator with generator polynomial

$$G = x^8 + x^4 + x^3 + x^2 + 1$$

and initial state

$$X_0 = (1,1,1,1,1,1,1,1)$$

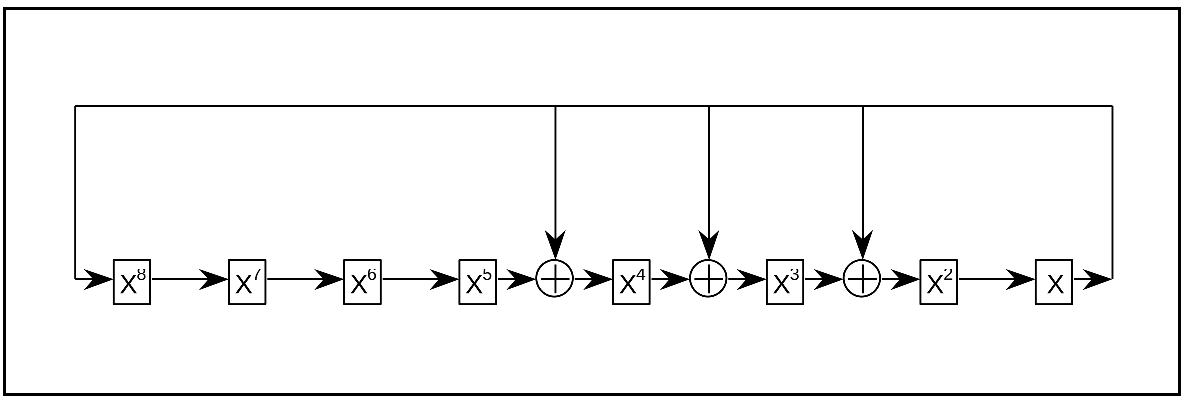

Fig. 2: Preamble sequence generator

as shown in Fig. 2 in canonical form.

The preamble is given in Table 1. The preamble is transmitted from the table by row from left to right, starting at the upper-left corner.

Table 1: Preamble Symbol Sequence.

1	0	1	1	1	1	0	0	1	1	0	1	1	1	0	1
1	1	0	0	1	0	1	0	1	0	0	1	0	1	0	0
0	1	0	0	1	0	1	1	0	1	0	0	0	1	1	0
0	1	1	1	0	0	1	1	1	1	0	0	0	1	1	0
1	1	0	0	0	0	1	0	0	0	1	0	1	1	1	0
1	0	1	1	1	1	0	1	1	0	1	1	1	1	1	0
0	0	0	1	1	0	1	0	0	1	1	0	1	0	1	1
0	1	1	0	1	0	1	0	0	0	0	0	1	0	0	1
1	1	0	1	1	0	0	1	0	0	1	0	0	1	1	0
0	0	0	0	0	1	1	1	0	1	0	0	1	0	0	0
1	1	1	0	0	0	1	0	0	0	0	0	0	0	1	0
1	1	0	0	0	1	1	1	1	0	1	0	0	0	0	1
1	1	1	1	1	0	1	0	0	1	0	0	0	0	1	0
1	0	0	1	1	1	1	1	0	1	0	1	0	1	0	1
1	1	0	0	0	0	0	1	1	0	0	0	1	0	1	0
1	1	0	0	1	1	0	0	1	0	1	1	1	1	1	-

7.3 Coding Frame Structure

The coding frame shall consist of user data encoded using the error-detection and correction (EDAC) technique defined herein.

7.3.1 Content, Transmission Order, Modulation, and Duration

The coding frame shall consist of a single codeword containing user data and redundant parity-checks for error detection and correction (EDAC). The coding frame can be configured to one of the specified codeword structures at modem initialization. The information content of the coding frame is fixed at 608 binary digits (bits) of user data[1]. The bits in the coding frame shall be arranged in groups of eight bits (i.e., bytes), and transmitted in the order shown in Fig. 3. Bits in the coding frame shall be transmitted in binary NRZ format as specified in para 5.

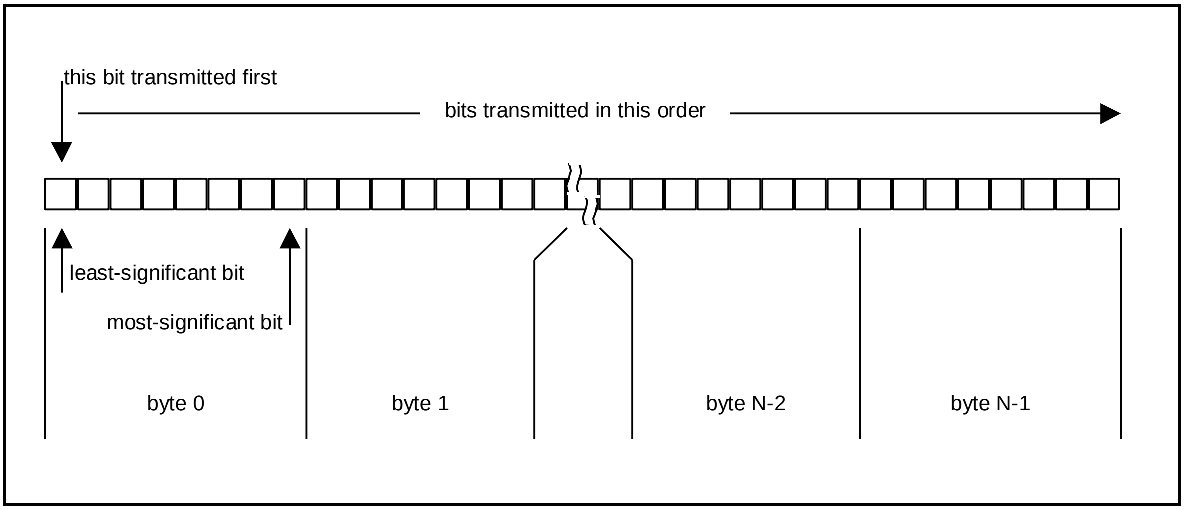

Fig. 3: Coding frame contents and bit transmission order. The coding frame duration is 48 msec

7.3.2 Coding Scheme

The coding scheme is one of a family of Reed-Solomon EDAC codes on GF(2^8), created by selecting a shortened codeword with the required information capacity and error-correction capabilities. The specific coding scheme chosen uses a codeword consisting of 76 eight-bit information symbols and 20 eight-bit parity symbols, i.e., the coding scheme shall be a (96,76) Reed-Solomon code defined on GF(2^8).

7.3.2.1 Mapping of User Bits

[1] This corresponds to 76 bytes of user data, i.e., 8 words (72 bytes or 576 bits) of Link 22 data and 4 bytes (32 bits) that may be used for Link 22 service headers.

No specific requirements on the modem interface are presented here. The bit mapping requirements defined here are defined with respect to a serial interface that imposes a natural sequence order on the user-bits as they are input to the modem. Other interfaces may be adopted so long as the user bits may be mapped into a serial form to which this specification can be applied.

User-bits shall be grouped in eight-bit symbols in the order in which they are presented on the interface, the earliest occurring bit in the group corresponding to the least-significant bit (LSB) of the symbol, the latest occurring bit in the group corresponding to most-significant bit (MSB) of the symbol.

Let $\{b_i, i = 0, N_b-1\}$, be a sequence of user bits of length N_b. The corresponding sequence of user information symbols on the field $GF(2^8)$ is defined as follows:

$$\{ I_j = (b_{8j+7}, b_{8j+6}, \ldots\ldots, b_{8j+1}, b_{8j})\} \quad \forall j \in \{0, \lfloor \frac{N_b}{8} \rfloor \} \qquad \text{(eq. 7.1)}$$

If there are insufficient user-bits to form an integral number of user-information symbols, then (N_b modulo 8) binary-zero padding bits shall be appended to the user bits prior to symbol formation.

7.3.2.2 Field Generator

The polynomial generator of the Galois Field $GF(2^8)$ shall be:

$$p(z) = z^8 + z^5 + z^3 + z + 1 \qquad \text{(eq. 7.2)}$$

The elements of the field generated by p(z) are:

$$0, 1, \alpha, \alpha^2, .., \alpha^{253}, \alpha^{254} \qquad \text{(eq. 7.3)}$$

Alternatively, each element in the Galois Field defined may be represented as an eight-bit binary character representation of the user-bits, as defined by eq. 7.1. In the RS codeword, any symbol is an element in $GF(2^8)$.

7.3.2.3 Code Generator

Let (n,k) be the parameters of the RS codeword, and define

$$R = (n-k) = (96 - 76) = 20.$$

The corresponding RS code shall be generated by the following code generator polynomial:

$$g(x) = (x - \alpha)(x - \alpha^2) \ldots (x - \alpha^R) \qquad \text{(eq. 7.4)}$$

7.3.2.4 Systematic Encoding

Let i(x) be the polynomial representing the k=76 user-information symbols to be coded as specified in para. 7.3.2.1, i.e.:

$$i(x) = I_1x^{k-1} + I_2x^{k-2} + \ldots. + I_{K-1}x + I_k \qquad \text{(eq. 7.5)}$$

The RS(n,k) codeword shall be represented in systematic form by the polynomial c(x) as follows:

$$c(x) = i(x)x^{n-k} + r(x) \qquad \text{(eq. 7.6)}$$

where,

$$r(x) = [i(x)x^{n-k}]\mathrm{mod}[g(x)] = R_1x^{n-k-1} + R_2x^{n-k-2} + \ldots + R_{n-k} \qquad \text{(eq. 7.7)},$$

i.e., r(x) is the polynomial remainder after dividing the information polynomial i(x) by the generator polynomial g(x).

After calculation, the codeword polynomial is represented as:

$$c(x)=I_1x^{k-1} + I_2x^{k-2} + \ldots + I_{K-1}x + I_k + R_1x^{n-k-1} + R_2x^{n-k-2} + \ldots + R_{n-k} \qquad \text{(eq.7.8).}$$

The resulting n-symbol codeword shall be the codeword polynomial represented in vector notation, as follows:

$$Cw = (I_1, I_2, \ldots, I_k, R_1, R_2, \ldots, R_{n-k-1}, R_{n-k}) \qquad \text{(eq. 7.9)}$$

where each symbol belongs to the Galois Field defined in eq. 7.2, and shall be represented by an eight-bit character as defined in para. 7.3.2.2.

7.3.2.5 Code Word Transmission

The transmission order of the codeword shall be in accordance with the decreasing order of its polynomial representation as specified in eq 7.6 and 7.7 with the result that the transmission order of the RS codeword symbols shall be in increasing index of the polynomial coefficients, as follows:

$$I_1 , I_2 , ..., I_k, R_1 , R_2 , ..., R_{n-k-1}, R_{n-k} \quad \text{(eq. 7.10)}$$

7.3.2.6 Decoding

The decoder shall perform error detection and correction on the received codeword. The decoder distance information, i.e., the Hamming distance between the received codeword and closest valid codeword, shall be provided as a Link-Quality Indicator.

7.4 Propagation Guard

The guard time shall be equal to the transmission time of two code-words less the preamble duration and the transmit guard, i.e., equal to the transmission time for 384 + 384 - 352 - 255 = 161 bits, or 10.0625 msec. When transmitting, the transmitter keyline shall be disabled at the beginning of the Propagation Guard.

8. SWITCHING TIME

It is recommended that the transmitter attack time should not be more than 22ms and release time not more than 10ms.

Receiver attack time shall not be more than 30ms and release time not more than 60ms.

ANNEX D TECHNICAL STANDARDS TO ENSURE INTEROPERABILITY OF SINGLE CHANNEL UHF RADIO EQUIPMENT for HIGH DATA RATE APPLICATIONS

1. Introduction

This appendix specifies the characteristics of a single channel UHF radio equipment to be used for High Data Rate Applications as follows:

- MARLIN Waveform as specified in STANAG 4691
- Other Single Carrier Waveforms with an RF bandwidth of up to 500kHz

2. Frequency Range

The nominal frequency range for RF carriers shall be from 225 MHz to 399.975 MHz, as specified in STANAG 4205, ANNEX B, paragraph 1.

Note: The user is responsible to ensure that no spectrum is falling outside the band. Therefore the channel frequency must be selected to be well within the band limits in the case that a broadband modulation is used.

3. Tuning

Radio frequency carriers shall be tuned to an integral multiple of 25 kHz, starting at 225 MHz, as specified in STANAG 4205, ANNEX B, paragraph 2.

4. Switching Time

4.1 It is recommended that the transmitter attack time shall not be more than 22ms and release time not more than 10ms.

4.2 Receiver attack time shall not be more than 30ms and release time not more than 60ms.

5. Frequency Accuracy

Radio-frequency carrier accuracy, including tolerance and long-term frequency stability but not any effects due to Doppler shift shall be within ±2 ppm.

6. Baseband and Control Interfaces

For the use of external data modems to the radio at least one of the following interfaces shall be supported:

- Wideband analog baseband interface
- 70MHz IF Interface
- Supporting control lines if necessary

The use of the wideband analog baseband interface may be limited in bandwidth. The full data rate capability may be only available by using the 70MHz IF Interface.

7. Modulation

7.1 For the wideband analogue interface as specified under 8 the carrier shall be double-sideband amplitude modulated, with a peak modulation index of not less than 0.85.

7.2 For the 70MHz IF Interface any single carrier modulation scheme may be applied.

Note: The setting of the transmit output power may be adjusted to the characteristics of the applied waveform e.g. crest factor to avoid overmodulation or clipping of the transmitted signal.

8 Wideband Analog Baseband Interfaces

8.1 Frequency Response

The baseband frequency response of the transmitter and of the receiver over the range 100Hz to 16kHz shall be within +/-2dB of the response at 1000Hz.

8.2 Signal Level

The radio shall support the operation with external modems adjustable in the range between 1Vpp (peak to peak) and 8Vpp (peak to peak) @ 600 Ohms.

8.3 Throughput Delay

It is recommended that the throughput delay of the transmitter baseband interface is not more than 1ms.

9 70MHz IF Interfaces

9.1 Impedance

The Impedance for input and output shall be 50 Ohms with a VSWR of not more than 2,5:1.

9.2 Sideband Inversion

The radio may operate with or without sideband inversion. The radio manufacturer shall state whether the equipment is inverting sidebands or not to allow a proper adjustment in the system.

9.3 Signal Level

9.3.1 The radio should be able to operate with input signal levels of typically -20dBm to -10dBm. (TX direction from modem to radio)

9.3.2 The radio should limit the maximum output signal level to typically -10dBm. (RX direction from radio to modem)

9.4 Throughput Delay

It is recommended that the throughput delay of the radio is not more than 1ms in transmit and receive mode.

9.5 Linearity in Transmit Mode

The radio shall fulfill the following linearity requirements:

EVM (error vector magnitude) less or equal than 10% operated with a single carrier waveform modulated with QPSK and filtered with a root raised cosine filter with a roll off factor of 0.5.

9.6 Passband Bandwidth

not less than +/-250kHz at -4dB.

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