**DEFENSE INFORMATION SYSTEMS AGENCY**

**JOINT INTEROPERABILITY TEST COMMAND**
**FORT HUACHUCA, ARIZONA**

# STANAG 4529
# CONFORMANCE
# TEST PROCEDURES

**APRIL 2004**

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Submitted by:          **Bradley A. Clark**
                       **Chief**
                       **Transport Systems Branch**


Approved by:           *Leslie F. Claudio*
                       **LESLIE CLAUDIO**
                       **Chief**
                       **Networks and Transport Division**


**Prepared Under the Direction Of:**

**Joseph Schulte**
**Joint Interoperability Test Command**
**Fort Huachuca, Arizona 85613-7051**

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# INTRODUCTION

The North Atlantic Treaty Organization Standardization Agreement (STANAG) 4529 establishes mandatory standards and design objectives that are necessary to ensure conformance for single-tone data modulators-demodulators (modems) for Maritime High Frequency (HF) radios, which establish links using 1240-Hertz (Hz) bandwidth signals.

This document contains the test procedures that will be used to determine the level of compliance of single-tone data modems to the requirements of STANAG 4529. This test plan is intended to be generic and can be used to test any equipment that requires conformance to the STANAG 4529.

If test item performance does not meet a requirement, the failure and its potential operational impact will be discussed in the follow-on test report and/or certification letter. Any requirement capabilities that are not implemented will also be discussed.

The Joint Interoperability Test Command will conduct testing at Fort Huachuca, Arizona.

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# TEST PROCEDURES

**MODULATION RATES, DATA RATES, TIMING, AND SYNCHRONIZATION**

**1.1    Objective.**  To determine the extent of compliance to the requirements of Standardization Agreement (STANAG) 4529, reference numbers 1-17.

**1.2    Criteria**

      **a.**      This document describes the modulation, call establishment process, and data correction required to ensure interoperability between modems transmitting data over High Frequency (HF) radio links where the data rate at the digital interface may be 75, 150, 300, 600, or 1200 bits per second (bps).  The rate at which data (user data bits plus bits for error correction coding) is transmitted (i.e., the channel data rate) may be a 600 bps (when the user data rate is 75, 150, or 300 bps), 1200 bps (when the user data rate is 600 bps), or 1800 bps (when the user data rate is 1200 bps).  The equipment may also be used for uncoded data transmission in which data input to a modulator's digital interface is transmitted without the addition of the error correction coding and interleaving described in paragraph 10.  The uncoded modes provide data rates of 600, 1200, and 1800 bps. (appendix B, reference numbers 1 and 2)

      **b.**      The modulation technique consists of phase shifting of a subcarrier frequency that is selectable in 100-hertz (Hz) steps from 800 to 2400 Hz inclusive. Modulation speed is 1200 bauds with a minimum accuracy of 1 part in $10^5$.  The accuracy of the clock linked with the generation of the subcarrier frequency is 1 part in $10^5$.  The phase shift of the modulated signal relative to the unmodulated reference subcarrier may take one of the specified values in table 1.1 and figure 1.1.   (appendix B, reference numbers 3-5)

### Table 1.1.  Symbol Number and Phase Conversion

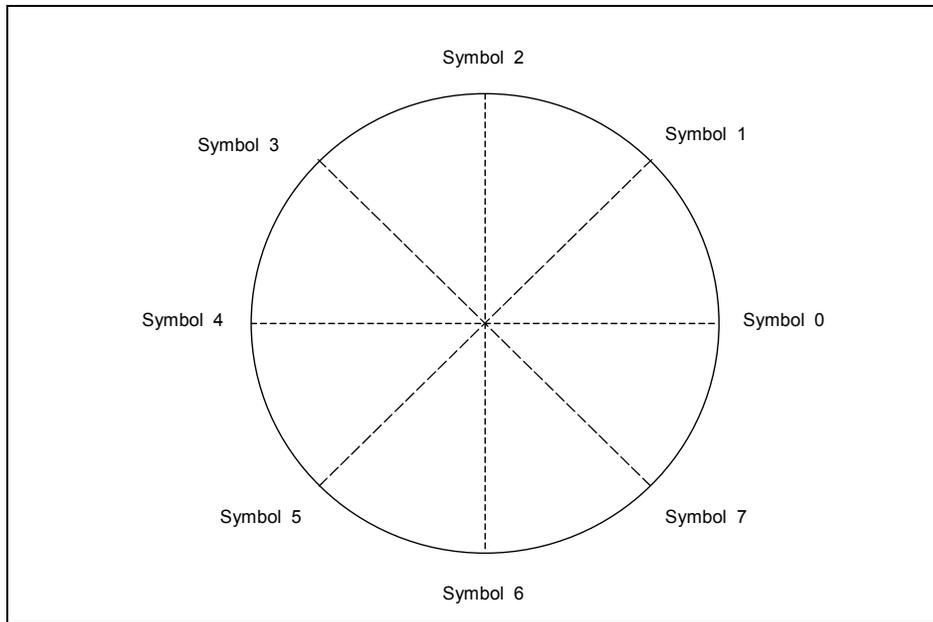| Symbol Number (n) | Phase |
|:---:|:---:|
| 0 | 0 |
| 1 | $\pi/4$ |
| 2 | $\pi/2$ |
| 3 | $3\pi/4$ |
| 4 | $\pi$ |
| 5 | $5\pi/4$ |
| 6 | $3\pi/2$ |
| 7 | $7\pi/4$ |
| **Note:**  The complex number exp[$jn\pi/2$] is linked with the symbol number n, where j is the imaginary number $\sqrt{-1}$. | |

**Figure 1.1.  Phase State Encoding**

       **c.**      For the 600 bps channel data rate (75, 150, and 300 bps user data rates), transcoding is achieved by linking one symbol to one bit according to table 1.2.  For the 1200 bps channels data rate (600 bps user data rate), transcoding is achieved by linking one symbol to a set of two consecutive bits (dibit) according to table 1.3.  For the 1800 bps channel data rate (1200 bps user data rate), transcoding is achieved by linking one symbol to a set of three consecutive bits (tribit) according to table 1.4. (appendix B, reference numbers 6-8)

**Table 1.2.  Bit Value and Symbol Linking for 600 bps Channel Rate**

| Bit | Symbol |
|:---:|:---:|
| 0 | 0 |
| 1 | 4 |

**Table 1.3.  Bit Value and Symbol Linking for 1200 bps Channel Rate**

| Dibit | Symbol |
|:---:|:---:|
| 00 | 0 |
| 01 | 2 |
| 11 | 4 |
| 10 | 6 |
| ↑ | |
| Most recent bit | |

**Table 1.4.  Bit Value and Symbol Linking for 1800 bps Channel Rate**

| Tribit | Symbol |
|--------|--------|
| 000 | 1 |
| 001 | 0 |
| 010 | 2 |
| 011 | 3 |
| 100 | 6 |
| 101 | 7 |
| 110 | 5 |
| 111 | 4 |
| ↑ Most recent bit | |

       **d.**      The power spectral density of the modulated signal shall be centered on a frequency that is selectable in 100 Hz to 2400 Hz inclusive, with a default value of 1700 Hz.  Filtering shall be applied as necessary so that 99 percent (%) of the output power is within 1240 Hz.  (appendix B, reference numbers 9-10)

       **e.**      The symbols to be transmitted are structured in recurrent frames 213.3 milliseconds (ms) in length as shown in figure 1.2.  A frame consists of 256 symbols.  A frame can be broken down into: 80 symbols for synchronization, 48 reference symbols, and 128 data symbols.  The 176 reference and data symbols are scrambled by a scrambling sequence with eight-phase-states of length 176.  The reference and data symbols are formed into 4 blocks:  the first 3 consist of 32 data symbols followed by 16 reference symbols; the last block consists of 32 symbols.  The reference symbols are all symbol number 0.  (appendix B, reference number 11)
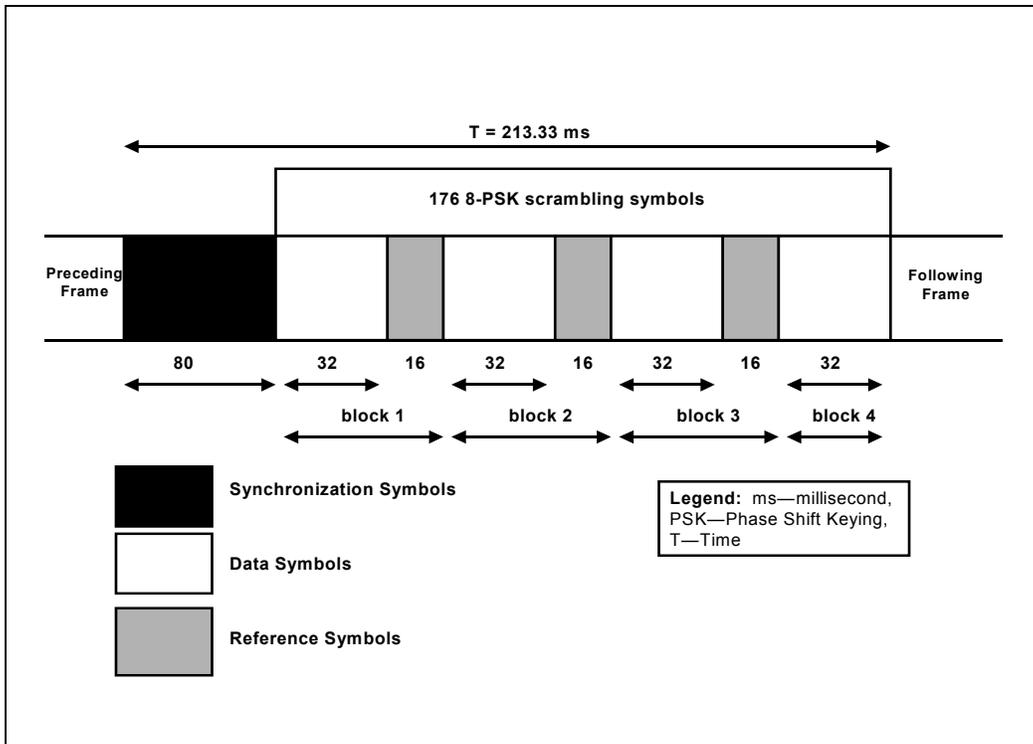
T = 213.33 ms

176 8-PSK scrambling symbols

Preceding Frame

Following Frame

| 80 | 32 | 16 | 32 | 16 | 32 | 16 | 32 |

block 1   block 2   block 3   block 4

Synchronization Symbols

Data Symbols

Reference Symbols

Legend: ms—millisecond, PSK—Phase Shift Keying, T—Time

**Figure 1.2.  Frame Structure**

**f.**      The synchronization consists of 80 symbols and is transmitted recurrently every 213.3 ms.  This sequence uses 2-bit phase shift keying (2-PSK) modulation and the modulation rate is equal to 1200 bauds.  The sequence is identical to a pseudo-random sequence of length 31, which is repeated periodically within the 80-symbol window, i.e., the synchronization sequence consists of 2 periods of length 31 plus the first 18 symbols of another period.  A generator for the synchronization sequence is described in figure 1.3.  The generator polynomial is:  $x^5 + x^2 + 1$.  At the beginning of every frame the generator is initially set to the following value:  11010.  The first symbol of the synchronization sequence is identical to the least significant bit of this initial value. The remaining 79 symbols are obtained by applying the clock 79 times. (appendix B, reference number 12)
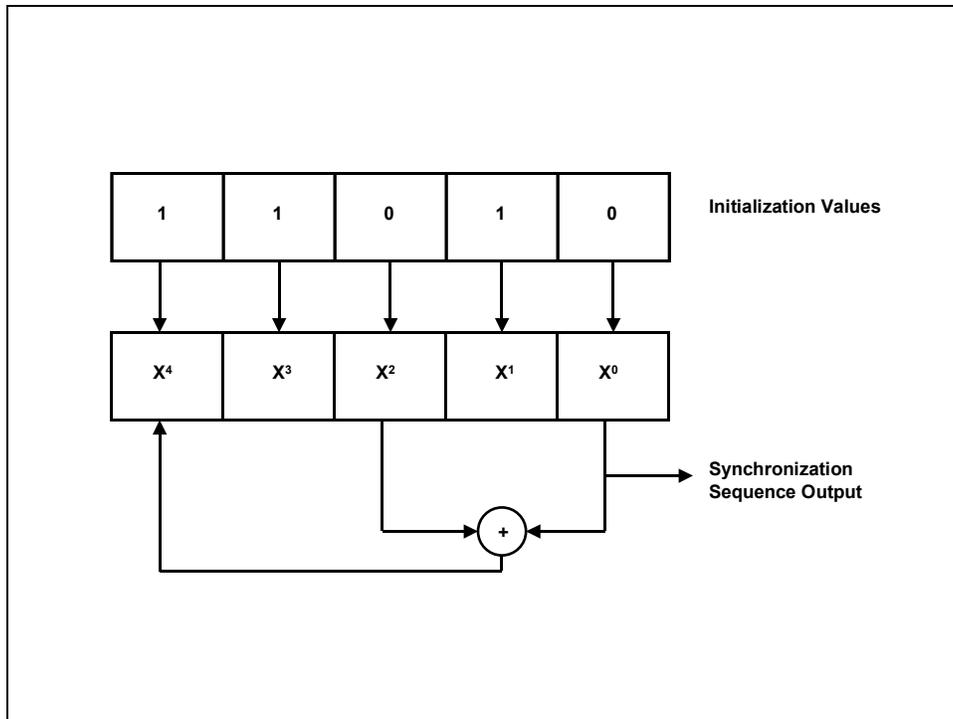
| 1 | 1 | 0 | 1 | 0 | Initialization Values |
|---|---|---|---|---|

| $X^4$ | $X^3$ | $X^2$ | $X^1$ | $X^0$ |
|---|---|---|---|---|

Synchronization Sequence Output

**Figure 1.3.  Synchronization Sequence Generator**

**g.**      The scrambling sequence is composed of 176 symbols and is repeated every 213.3 ms.  This sequence is transmitted in eight-phase-state modulation at the rate of 1200 bauds.  Data scrambling by an eight-phase-state sequence is done to maintain commonality with STANAG 4285 implementations.  The scrambling symbol generator is shown in figure 1.4.  The symbols are formed by means of a pseudo-random code of length 511, the generator polynomial of which is:  $x^9 + x^4 + 1$.  The generator is initialized to 1 at the start of each frame.  A symbol is derived from the triplet consisting of the last three bits in the Pseudo-random Numerical (PN) register, i.e., $x_0 x_1 x_2$ by the following relationship:

Scrambling symbol $B_k = \exp[jn\pi/4]$
Where:
$n = 4x_2 + 2x_1 + x_0$

$x_0 = 0$ or 1

$x_1 = 0$ or 1

$x_2 = 0$ or 1

Generation from one symbol to the next is by successive shifting of the PN register by three positions.  (appendix B, reference number 13)
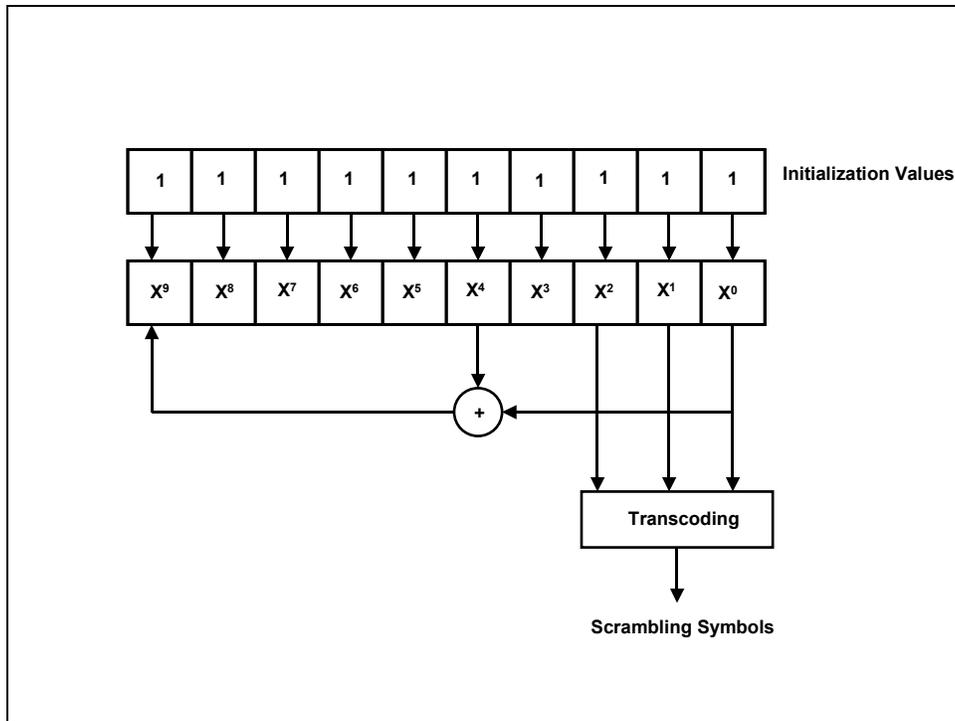
7

**1** **1** **1** **1** **1** **1** **1** **1** **1** **1**    **Initialization Values**

$X^9$   $X^8$   $X^7$   $X^6$   $X^5$   $X^4$   $X^3$   $X^2$   $X^1$   $X^0$

**+**

**Transcoding**

**Scrambling Symbols**

**Figure 1.4.  Generation of Scrambling Sequence**

**h.** The scrambling operation is carried out on reference and data symbols only, not on the synchronization sequence.  This operation consists of module 8 addition of the data symbol number to the scrambling symbol number; this amounts to complex multiplication of the data symbol by the scrambling symbol.  (appendix B, reference number 14)

**i.** The modem must be capable of tolerating a frequency error of +/-37.5 Hz between the transmission and reception of HF carriers (transmitter/receiver frequency error and Doppler shift included) and rate of frequency change of up to 3.5 Hz/second (sec).  (appendix B, reference number 15)

**j.** For the error correction modes defined in this STANAG, the error correction coding used shall be the rate ½, constraint length 7 convolutional coding as described STANAG 4285, annex E.  For each user data rate described in this STANAG (i.e., 75, 150, 300, 600, and 1200 bps) the coding, interleaving, and flush bits shall be as described for the higher data rate in STANAG 4285, annex E.  The changes necessary to allow 1240-Hz operation are explicitly shown, in table 1.5.  The error correction coding used shall be as in STANAG 4285, annex E, section 2 with the following changes as shown in table 1.5.

## Table 1.5. Error Correction Coding

| Coded data area | Waveform | Effective code rate | Coding method |
|---|---|---|---|
| 1200 bps | 8 phase (1800 bps) | 2/3 | Rate 1/2 punctured to rate 2/3 |
| 600 bps | 4 phase (1200 bps) | 1/2 | Rate 1/2 code |
| 300 bps | 2 phase (600 bps) | 1/2 | Rate 1/2 code |
| 150 bps | 2 phase (600 bps) | 1/4 | Rate 1/2 code repeated 2x |
| 75 bps | 2 phase (600 bps) | 1/8 | Rate 1/2 code repeated 4x |
| **Legend:** bps—bits per second | | | |

The interleaving shall be as described in STANAG 4285, annex E, section 3 with the following different parameters:

Number of rows: I = 32 for all data rates

Delay increment "j" for each successive row:

Total Interleaving Delay:

| Data rates | 20.48 sec | 1.706 sec |
|---|---|---|
| 1200 bps | 48 | 4 |
| 600 bps | 24 | 2 |
| 300, 150 and 75 bps | 12 | 1 |

Interleaver synchronization shall be as described in STANAG 4285, annex E, part 4 with no changes. The initialization and message protocol for use with coding and interleaving shall be as described in STANAG 4285, annex E, part 5 with the following difference:

The number of flush zeros for each of the data rates and the two interleaver lengths are as follows: (appendix B, reference number 16)

Interleaver Delay

| Data rate | 20.48 sec | 1.706 sec |
|---|---|---|
| 1200 bps | 24678 | 2150 |
| 600 bps | 12390 | 1126 |
| 300 bps | 6246 | 614 |
| 150 bps | 3174 | 358 |
| 75 bps | 1638 | 230 |

**k.** Modems shall provide uncoded data transmission modes, in which the coding, interleaving, and associated initialization and message protocols (described in section 10 of STANAG 4529) are not applied to the data transmitted. Uncoded data modes shall retain all other characteristics described in STANAG 4529, annex A, paragraph 11. Uncoded data rates of 600, 1200, and 1800 bps shall be provided. (appendix B, reference number 17)

## 1.3  Test Procedures

    **a.**    Test Equipment Required

        (1)    Bit Error Rate Tester (BERT) (2 each)

        (2)    Vector Signal Analyzer

        (3)    Personal Computer

        (4)    Spectrum Analyzer

        (5)    Unit Under Test (UUT)

        (6)    High Frequency (HF) Simulator

        (7)    Modem (similar to UUT)

    **b.**    Test Configuration.  Figures 1.5, 1.6, 1.7, and 1.8 shows the equipment setup for this test.
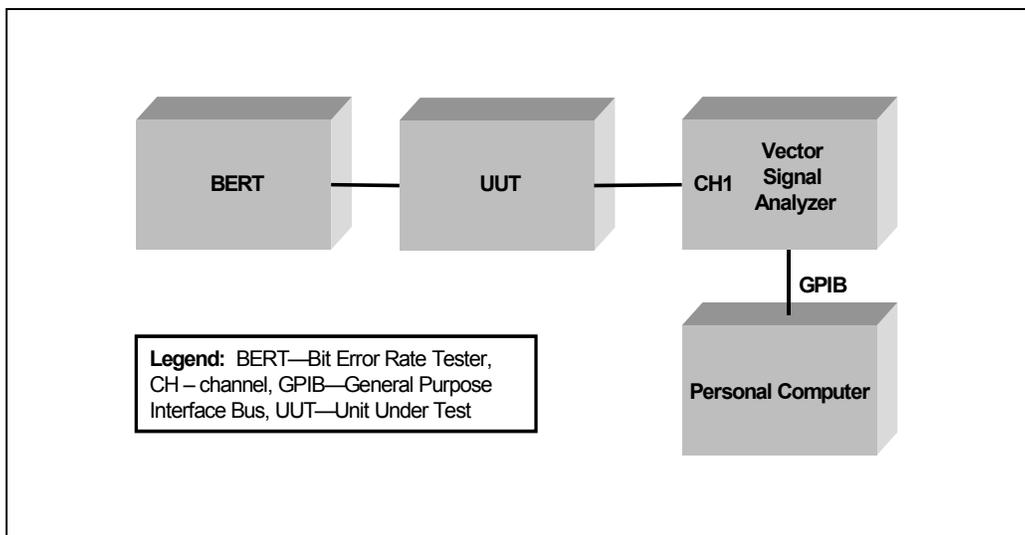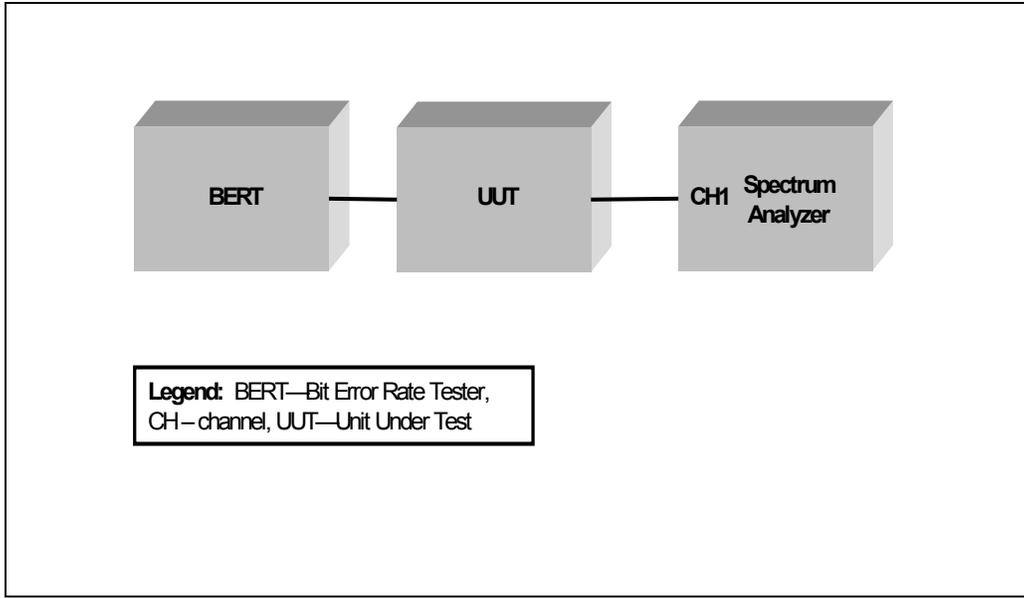


**Figure 1.5.  Equipment Configuration for Data Analysis**

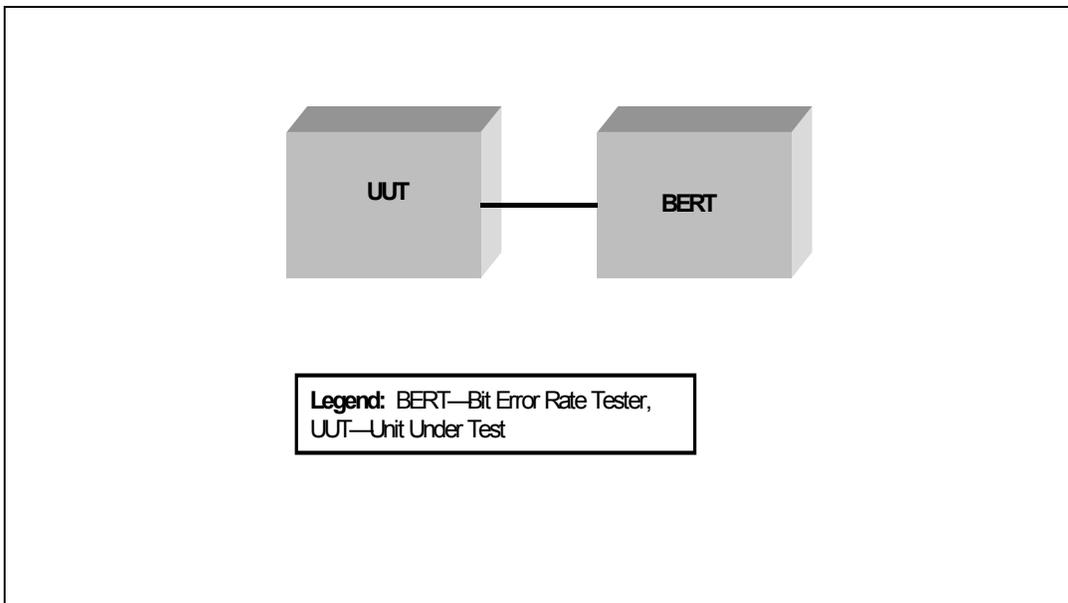**Figure 1.6. Equipment Configuration for Output Power Measurements**



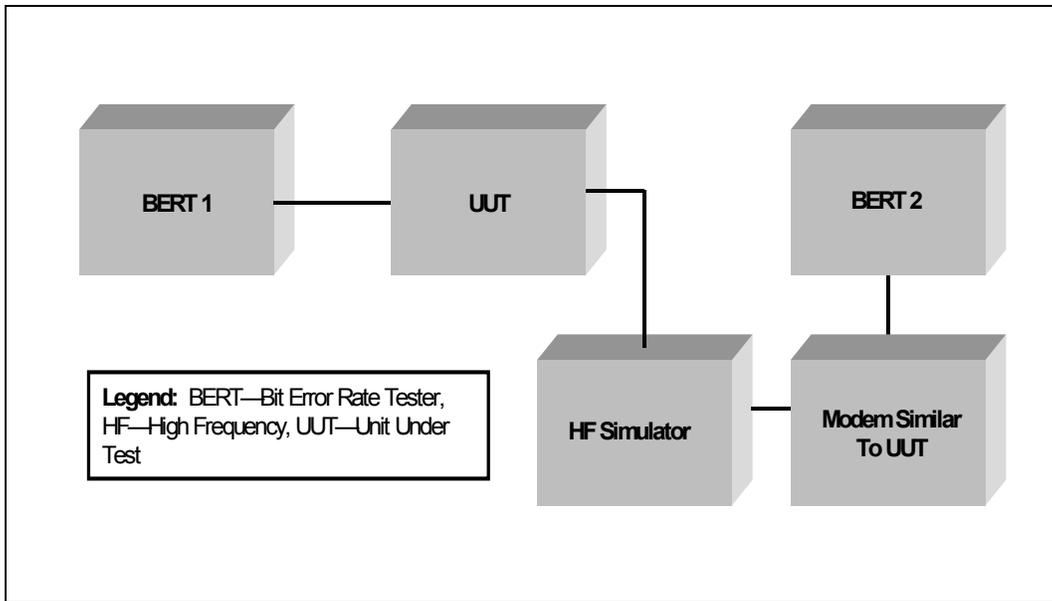**Figure 1.7. Equipment Configuration for Clock Accuracy**

**Figure 1.8.  Equipment Configuration for Frequency Error**

**c.**     Test Conduct.  The procedures for this test are listed in table 1.6.

**Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| The following procedures are for reference numbers 1, 2, and 12. ||||
| 1 | Set up equipment. | Set up equipment as shown in figure 1.5. Configure the vector analyzer so its phase state diagram is as specified in figure 1.1 and tables 1.2, 1.3, and 1.4. | |
| 2 | Configure vector signal analyzer. | Frequency<br>  Center: 2 kHz<br>  Span: 1.24 kHz<br>Time<br>  Result Length: 2000 symbols<br>  Search Length: 853.33 ms<br>Sync Setup<br>  Pattern: 01011001111100011011<br>  Offset: 0 symbols<br>Instrument Mode<br>Digital Demodulation<br>Demodulation Setup<br>  Demodulation Format: BPSK<br>  Symbol Rate: 1.2 kHz<br>  Result Length: 1000 symbols<br>  Reference Filter: Raised Cos<br>  Meas Filter: Root Raised Cos<br>  Alpha: 0.16<br>  Sweep: Single<br>Trigger<br>  Trigger Type: IF CH1<br>Configure state constellation diagram as given in figure 1.1. | |
| 3 | Configure UUT. | Configure the UUT to transmit using a STANAG 4529 coded, 75 bps, short interleaving waveform. Configure the subcarier frequency to 2000 Hz. | |
| 4 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 5 | Transmit data. | Allow for the BERT to transmit its data through the UUT. Save the data captured on the vector signal analyzer to a file. | |

**Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 6 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 7 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 75 bps, long interleaving. | |
| 8 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 9 | Transmit data. | Allow for the BERT to transmit its data through the UUT. Save the data captured on the vector signal analyzer to a file. | |
| 10 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 11 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 150 bps, short interleaving. | |
| 12 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 13 | Transmit data. | Allow for the BERT to transmit its data through the UUT. Save the data captured on the vector signal analyzer to a file. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 14 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 15 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 150 bps, long interleaving. | |
| 16 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 17 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 18 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 19 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 300 bps, short interleaving. | |
| 20 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 21 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 22 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 23 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 300 bps, long interleaving. | |
| 24 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 25 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 26 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 27 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 600 bps, short interleaving. | |
| 28 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 29 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 30 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 31 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 600 bps, long interleaving. | |
| 32 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 33 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 34 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 35 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 1200 bps, short interleaving. | |
| 36 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 37 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 38 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 39 | Re-configure UUT. | Re-configure the UUT to transmit with coded, 1200 bps, long interleaving. | |
| 40 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 41 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 42 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 43 | Re-configure vector signal analyzer. | Re-configure the vector signal analyzer's demodulation format to BPSK and to sync on the following sequence: 01011001111100011011. | |
| 44 | Re-configure UUT. | Re-configure the UUT to transmit with uncoded, 600 bps (if available). | |
| 45 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 46 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 47 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 48 | Re-configure UUT. | Re-configure the UUT to transmit with uncoded, 1200 bps (if available). | |
| 49 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 50 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 51 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| 52 | Re-configure UUT. | Re-configure the UUT to transmit with uncoded, 1800 bps (if available). | |
| 53 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 54 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 55 | Verify vector signal analyzer was able to synchronize. | On the vector signal analyzer screen, compare the following BPSK synchronization sequence pattern to the pattern that the vector signal analyzer synchronized on:<br><br>0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 1 1<br>1 0 1 0 1 0 0 0 0 1 0 0 1 0 1 1 0 0 1 1<br>1 1 1 0 0 0 1 1 0 1 1 1 0 1 0 1 0 0 0 0<br>1 0 0 1 0 1 1 0 0 1 1 1 1 1 0 0 0 1 1 0 | |
| *The following procedures are for reference numbers 5-8, 11, 13-14, and 16.* | | |
| 56 | The following procedures use automated software to decode STANAG 4529 data transmitted from the UUT.  The test operator must program the UUT to transmit the following test pattern:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII.<br><br>The automated software is available for download from the JITC website: http://jitc.fhu.disa.mil/it/hf.htm | Successful decode of the STANAG 4529 data validates that the following requirements have been met:  FEC encoder, interleaver, frame synchronization symbols, scrambler, reference symbols, frame structure, and transcoding. | |
| 57 | Copy and paste STANAG4529.vi file onto hard disk of personal computer containing LabVIEW software. | Copy and paste 4529.STA file onto a 3.5-inch floppy disk.  Insert floppy disk into drive a: of vector signal analyzer. | |
| 58 | Connect the UUT to channel 1 of the vector signal analyzer. | Connect the vector signal analyzer to personal computer via the GPIB interface. | |
| 59 | Load LabVIEW software. | Open STANAG4529.vi. | |
| 60 | Program the UUT to send STANAG 4529 data at coded 75 bps, using the short interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 61 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 62 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |

**Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 63 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 64 | Program the UUT to send STANAG 4529 data at coded 75 bps, using the long interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 65 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 66 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 67 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 68 | Program the UUT to send STANAG 4529 data at coded 150 bps, using the short interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 69 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 70 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 71 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 72 | Program the UUT to send STANAG 4529 data at coded 150 bps, using the long interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 73 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 74 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 75 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 76 | Program the UUT to send STANAG 4529 data at coded 300 bps, using the short interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 77 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 78 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 79 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 80 | Program the UUT to send STANAG 4529 data at coded 300 bps, using the long interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 81 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 82 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 83 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 84 | Program the UUT to send STANAG 4529 data at coded 600 bps, using the short interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 85 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | Re-configure the vector signal analyzer Demodulation Setup:  Demodulation Format to 4-PSK. | |
| 86 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |

## Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 87 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 88 | Program the UUT to send STANAG 4529 data at coded 600 bps, using the long interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 89 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 90 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 91 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 92 | Program the UUT to send STANAG 4529 data at coded 1200 bps, using the short interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 93 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | Re-configure the vector signal analyzer Demodulation Setup: Demodulation Format to 8-PSK. | |
| 94 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 95 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer). Save encoded data to file. | |
| 96 | Program the UUT to send STANAG 4529 data at coded 1200 bps, using the long interleaver and a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 97 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | | |
| 98 | Run STANAG4529.vi file. | Observe vector signal analyzer. When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |

# Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 99 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| | The following procedures are for reference number 17. | | |
| 100 | Program the UUT to send STANAG 4529 data at uncoded 600 bps, using a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 101 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | Re-configure the vector signal analyzer Demodulation Setup:  Demodulation Format to BPSK. | |
| 102 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 103 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 104 | Program the UUT to send STANAG 4529 data at uncoded 1200 bps, using a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 105 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | Re-configure the vector signal analyzer Demodulation Setup:  Demodulation Format to 4-PSK. | |
| 106 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |
| 107 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 108 | Program the UUT to send STANAG 4529 data at uncoded 1800 bps, using a subcarrier frequency of 2000 Hz. | Ensure that the UUT is in the idle state (not sending). | |
| 109 | Use the automated software's Test Information box to select data rate, interleaver, and uncoded/coded type. | Re-configure the vector signal analyzer Demodulation Setup:  Demodulation Format to 8-PSK. | |
| 110 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern stated in step 56. | |

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 111 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |

**Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| | The following procedures are for reference number 3. | | |
| 112 | Configure vector signal analyzer. | Frequency<br>  Center:  800 Hz<br>  Span:  1.24 kHz<br>Time<br>  Result Length:  2000 symbols<br>  Search Length:  853.33 ms<br>Sync Setup<br>   Pattern:  01011001111100011011<br>   Offset:  0 symbols<br>Instrument Mode<br>Digital Demodulation<br>Demodulation Setup<br>  Demodulation format:  BPSK<br>  Symbol Rate:  1.2 kHz<br>  Result Length:  1000 symbols<br>  Reference Filter:  Root Raised Cos<br>  Meas Filter:  Root Raised Cos<br>  Alpha: 0.16<br>  Sweep:  Single<br>Trigger<br>  Trigger Type:  IF CH1<br>Configure state constellation diagram as given in figure 1.1 | |
| 113 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 800 Hz. | |
| 114 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 115 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 116 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 117 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 118 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 900 Hz. | |
| 119 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 900 Hz. | |
| 120 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 121 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 122 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 123 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 124 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1000 Hz. | |
| 125 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 1000 Hz. | |
| 126 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 127 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 128 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 129 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 130 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1100 Hz. | |
| 131 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving.  Configure the subcarier frequency to 1100 Hz. | |
| 132 | Configure BERT. | Configure the BERT to transmit:  "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 133 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 134 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 135 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 136 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1200 Hz. | |
| 137 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving.  Configure the subcarier frequency to 1200 Hz. | |
| 138 | Configure BERT. | Configure the BERT to transmit:  "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 139 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 140 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 141 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 142 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1300 Hz. | |
| 143 | Configure UUT. | Configure the UUT to transmit with coded, 600 bps, short interleaving. Configure the subcarier frequency to 1300 Hz. | |
| 144 | Configure BERT. | Configure the BERT to transmit:  "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 145 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 146 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 147 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 148 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1400 Hz. | |
| 149 | Configure UUT. | Configure the UUT to transmit with coded, 600 bps, short interleaving. Configure the subcarier frequency to 1400 Hz. | |
| 150 | Configure BERT. | Configure the BERT to transmit:  "THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 151 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 152 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

## Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 153 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 154 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1500 Hz. | |
| 155 | Configure UUT. | Configure the UUT to transmit with coded, 600 bps, short interleaving.  Configure the subcarier frequency to 1500 Hz. | |
| 156 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 157 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 158 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 159 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 160 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1600 Hz. | |
| 161 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving.  Configure the subcarier frequency to 1600 Hz. | |
| 162 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 163 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 164 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 165 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 166 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1700 Hz. | |
| 167 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 1700 Hz. | |
| 168 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 169 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 170 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 171 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 172 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1800 Hz. | |
| 173 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 1800 Hz. | |
| 174 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 175 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 176 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

**Table 1.6. Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 177 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 178 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 1900 Hz. | |
| 179 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 1900 Hz. | |
| 180 | Configure BERT. | Configure the BERT to transmit:

"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 181 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 182 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 183 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 184 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 2000 Hz. | |
| 185 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 2000 Hz. | |
| 186 | Configure BERT. | Configure the BERT to transmit:

"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 187 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 188 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

## Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 189 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 190 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 2100 Hz. | |
| 191 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving.  Configure the subcarier frequency to 2100 Hz. | |
| 192 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 193 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 194 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 195 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 196 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 2200 Hz. | |
| 197 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving.  Configure the subcarier frequency to 2200 Hz. | |
| 198 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 199 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 200 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 201 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 202 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 2300 Hz. | |
| 203 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 2300 Hz. | |
| 204 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 205 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 206 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |
| 207 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| 208 | Re-configure center frequency on vector signal analyzer. | Re-configure the vector signal analyzer's center frequency setting to 2400 Hz. | |
| 209 | Configure UUT. | Configure the UUT to transmit with coded, 300 bps, short interleaving. Configure the subcarier frequency to 2400 Hz. | |
| 210 | Configure BERT. | Configure the BERT to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 211 | Transmit data. | Allow for the BERT to transmit its data through the UUT.  Save the data captured on the vector signal analyzer to a file. | |
| 212 | Run STANAG4529.vi file. | Observe vector signal analyzer.  When analyzer displays "Waiting for Trigger," key the modem and begin sending test pattern in step 114. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|---|---|---|---|
| 213 | Automated software will run for several minutes. | Record results of software decode. (Note that the operator may choose to view the raw data captured on the vector signal analyzer).  Save encoded data to file. | |
| *The following procedures are for reference numbers 9 and 10.* | | | |
| 214 | Set up equipment. | Set up the equipment as shown in figure 1.6. | |
| 215 | Configure spectrum analyzer. | Frequency Channel<br>    Center Frequency:  1.7 kHz<br>Span<br>    Span:  3 kHz<br>Input/Output<br>    RF Coupling:  DC<br>Measure<br>    Occupied Bandwidth<br>Measure Setup<br>     Occupied Bandwidth:  99% | |
| 216 | Configure BERT. | Configure the BERT to transmit the MARK pattern. | |
| 217 | Configure UUT. | Configure the UUT to transmit with a subcarrier frequency of 1.7 kHz with coded 600 bps and short interleaving. | |
| 218 | Verify occupied bandwidth. | Record the 99% occupied bandwidth frequency. | |
| *The following procedures are for reference number 4.* | | | |
| 219 | Set up equipment. | Set up the equipment as shown in figure 1.7. | |
| 220 | Configure BERT. | Analysis Results<br>    Signal:  Received Frequency | |
| 221 | Verify frequency. | The frequency the BERT is receiving from the UUT will be displayed under "Received Frequency."  Record the Received Frequency. | |
| *The following procedures are for reference number 15.* | | | |
| 222 | Set up equipment. | Set up the equipment as shown in figure 1.8. | |
| 223 | Configure BERT1. | Configure the BERT1 to transmit:<br><br>"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789" using 7-bit ASCII. | |
| 224 | Configure BERT2. | Analysis Results<br>    Error:  Bit Errors | |
| 225 | Configure HF Simulator. | Frequency Offset:  37.5 Hz<br>Sweep Rate:  3.5 Hz/sec | |
| 226 | Configure UUT. | Configure the UUT to transmit with coded, 600 bps, short interleaving. Configure the subcarier frequency to 1700 Hz. | |

**Table 1.6.  Modulation Rates, Data Rates, Timing, and Synchronization Procedures (continued)**

| Step | Action | Settings/Action | Result |
|------|--------|-----------------|--------|
| 227 | Run test. | Program BERT1 to transmit its message through the UUT for 5 minutes. | |
| 228 | Determine bit errors. | Record the number of bit errors received by BERT2. | |
| **Legend:** ASCII—American Standard Code for Information Interchange; BERT—Bit Error Rate Tester**;** bps—bits per second; BPSK—Binary Phase Shift Keying; CH1—Channel 1; Cos—Cosine; DC—Direct Current; FEC—Forward Error Correction; GPIB—General Purpose Interface Bus; HF—High Frequency; Hz—Hertz; IF—Intermediate Frequency; JITC—Joint Interoperability Test Command; kHz—Kilohertz; Meas—Measured; ms—millisecond; PSK—Phase Shift Keying; RF—Radio Frequency; sec—second; STANAG—Standardization Agreement; Sync—Synchronization; UUT—Unit Under Test ||||

**1.4. Presentation of Results.** The results will be shown in table 1.7 indicating the requirement and measured value or indications of capability.

**Table 1.7. Modulation Rates, Data Rates, Timing, and Synchronization Results**

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 1 | 1a | This document describes the modulation; call establishment process, and data correction required to ensure interoperability between modems transmitting data over HF radio links where the data rate at the digital interface may be 75, 150, 300, 600, or 1200 bps.  The rate at which data (user data bits plus bits for error correction coding) is transmitted (i.e., the channel data rate) may be a 600 bps (when the user data rate is 75, 150, or 300 bps), 1200 bps (when the user data rate is 600 bps), or 1800 bps (when the user data rate is 1200 bps). | Modem provides coded data rates of 75, 150, 300, 600, and 1200 bps. | | | |
| 2 | 1b | The equipment may also be used for uncoded data transmission in which data input to a modulator's digital interface is transmitted without the addition of the error correction coding and interleaving described in paragraph 10.  The uncoded modes provide data rates of 600, 1200, and 1800 bps. | (optional) Modem provides uncoded data rates of 600, 1200, and 1800 bps. | | | |
| 3 | 2a | The modulation technique consists of phase shifting of a subcarrier frequency that is selectable in 100-Hz steps from 800 to 2400 Hz inclusive. | Subcarier frequency selectable in 100 Hz increments with a range of 800 to 2400 Hz. | | | |
| 4 | 2b | Modulation speed is 1200 bauds with a minimum accuracy of 1 part in $10^5$. The accuracy of the clock linked with the generation of the subcarrier frequency is 1 part in $10^5$. | Received frequency on BERT is 1200.00 Hz. | | | |

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 5 | 2c | The phase shift of the modulated signal relative to the unmodulated reference subcarrier may take one of the following values. (see figure A-1).<br><br>Symbol Number      Phase<br>0            0<br>1            $\pi/4$<br>2            $\pi/2$<br>3            $3\pi/4$<br>4            $\pi$<br>5            $5\pi/4$<br>6            $3\pi/2$<br>7            $7\pi/4$<br><br>The complex number $\exp[jn\pi/2]$ is linked with the symbol number n. | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |
| 6 | 3a | For the 600 bps channel data rate (75, 150, and 300 bps user data rates), transcoding is achieved by linking one symbol to one bit according to the following rule:<br><br>Bit          Symbol<br>0             0<br>1             4 | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |
| 7 | 3b | For the 1200 bps channels data rate (600 bps user data rate), transcoding is achieved by linking one symbol to a set of two consecutive bits (dibit) according to the following rule:<br><br>Dibit       Symbol<br>00          0<br>01          2<br>11          4<br>10          6<br>↑<br>Most recent bit | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |

**Table 1.7. Modulation Rates, Data Rates, Timing, and Synchronization Results (continued)**

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 8 | 3c | For the 1800 bps channel data rate (1200 bps user data rate), transcoding is achieved by linking one symbol to a set of three consecutive bits (tribit) according to the following rule:<br><br>Tribit    Symbol<br>000    1<br>001    0<br>010    2<br>011    3<br>100    6<br>101    7<br>110    5<br>111    4<br>↑<br>Most recent bit | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |
| 9 | 4 | The power spectral density of the modulated signal shall be centered on a frequency that is selectable in 100-Hz steps from 800 Hz to 2400 Hz inclusive, with a default value of 1700 Hz. | Power spectral density centered at 1700 Hz. | | | |
| 10 | 4 | Filtering shall be applied as necessary so that 99% of the output power is within 1240 Hz. | 99% output power contained within 1240 Hz. | | | |
| 11 | 5 | The symbols to be transmitted are structured in recurrent frames 213.3 ms is length. A frame consists of 256 symbols. A frame can be broken down into: 80 symbols for synchronization, 48 reference symbols and 128 data symbols. The 176 reference and data symbols are scrambled by a scrambling sequence with eight-phase-states of length 176. The reference and data symbols are formed into 4 blocks: the first 3 consist of 32 data symbols followed by 16 reference symbols: the last block consists of 32 symbols. The reference symbols area all symbol number 0. | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |

**Table 1.7.  Modulation Rates, Data Rates, Timing, and Synchronization Results (continued)**

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
| | | | Required Value | Measured Value | Met | Not Met |
|---|---|---|---|---|---|---|
| 12 | 6 | The synchronization consists of 80 symbols and is transmitted recurrently every 213.3 ms. This sequence uses 2PSK modulation and the modulation rate is equal to 1200 bauds. The sequence is identical to a pseudo random sequence of length 31, which is repeated periodically within the 80 symbol window, i.e., the synchronization sequence consists of 2 periods of length 31 plus the first 18 symbols of another period.  A generator for the synchronization sequence is described in figure A-4. The generator polynomial is: $x^5 + x^2 +1$. At the beginning of every frame the generator is initially set to the following value:  11010. The first symbol of the synchronization sequence is identical to the least significant bit of this initial value.  The remaining 79 symbols are obtained by applying the clock 79 times. | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |

# Table 1.7.  Modulation Rates, Data Rates, Timing, and Synchronization Results (continued)

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 13 | 7 | The scrambling sequence is composed of 176 symbols and is repeated every 213.3 ms. This sequence is transmitted in eight-phase-state modulation at the rate of 1200 bauds.  Data scrambling by an eight-phase-state sequence is done to maintain commonality with STANAG 4285 implementations.  The scrambling signal generator is shown in figure A-5.  The symbols are formed by means of a pseudo-random code of length 511, the generator polynomial of which is:  $x^9 + x^4 + 1$.  The generator is initialized to 1 at the start of each frame.  A symbol is derived from the triplet consisting of the last three bits in the PN register, i.e., $x_0$ x1 x2 by the following relationship: Scrambling symbol $B_k = \exp[jn\pi/4]$ Where: $n = 4x_2 + 2x_1 + x_0$<br><br>$x_0 = 0$ or 1<br><br>$x_1 = 0$ or 1<br><br>$x_2 = 0$ or 1<br>Generation from one symbol to the next is by successive shifting of the PN register by three positions. | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |
| 14 | 8 | The scrambling operation is carried out on reference and data symbols only, not on the synchronization sequence.  This operation consists of modulo 8 addition of the data symbol number to the scrambling symbol number; this amounts to complex multiplication of the data symbol by the scrambling symbol. | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |

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**Table 1.7.  Modulation Rates, Data Rates, Timing, and Synchronization Results (continued)**

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 15 | 9 | The modem must be capable of tolerating a frequency error of +/-37.5 Hz between the transmission and reception of HF carriers (transmitter/receiver frequency error and Doppler shift included) and rate of frequency change of up to 3.5 Hz/sec. | 0 Bit Errors. | | | |

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 16 | 10 | For the error correction modes defined in this STANAG, the error correction coding used shall be the rate ½, constraint length 7 convolutional coding as described STANAG 4285, annex E. For each user data rate described in this STANAG (i.e., 75, 150, 300, 600, and 1200 bps) the coding, interleaving, and flush bits shall be as described for the higher data rate in STANAG 4285, annex E.  The changes necessary to allow 1240-Hz operation are explicitly shown below: The error correction coding used shall be as in STANAG 4285, annex E, section 2 with the following changes: See figure A-6. The interleaving shall be as described in STANAG 4285, annex E, section 3 with the following different parameters: Number of rows: I = 32 for all data rates Delay increment "j" for each successive row:<br><br>      Total Interleaving Delay:<br>Data rates   20.48 sec    1.706 sec<br>1200 bps      48           4<br>600 bps       24           2<br>300, 150,     12           1<br>and 75 bps<br>Interleaver synchronization shall be as described in STANAG 4285, annex E, part 4 with no changes.  The initialization and message protocol for use with coding and interleaving shall be as described in STANAG 4285, annex E, part 5 with the following difference: The number of flush zeros for each of the data rates and the two interleaver lengths are as follows:<br>         Interleaver Delay<br>Data rate   20.48 sec   1.706 sec<br>1200 bps    24678      2150<br>600 bps     12390      1126<br>300 bps      6246       614<br>150 bps      3174       358<br>75 bps       1638       230 | STANAG 4529 decode software developed by JITC capable of decoding data transmitted from UUT. | | | |

**Table 1.7.  Modulation Rates, Data Rates, Timing, and Synchronization Results (continued)**

| Reference Number | STANAG 4203 Paragraph | Requirement | Result | | Finding | |
|---|---|---|---|---|---|---|
| | | | Required Value | Measured Value | Met | Not Met |
| 17 | 11 | Modems shall provide uncoded data transmission modes, in which the coding, interleaving, and associated initialization and message protocols (described in section 10) are not applied to the data transmitted. Uncoded data modes shall retain all other characteristics described In this STANAG.  Uncoded data rates of 600, 1200, and 1800 bps shall be provided. | STANAG 4529 decode software developed by JITC capable of decoding data transmit-ted from UUT. | | | |
| **Legend:**  BERT—Bit Error Rate Tester; bps—bits per second; HF—High Frequency; Hz—hertz; JITC—Joint Interoperability Test Command; ms—millisecond; PN—Pseudo-random Numerical; PSK—Phase Shift Keying; sec—second; STANAG–Standardization Agreement; UUT—Unit Under Test | | | | | | |

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**APPENDIX A**

**ACRONYMS**

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# APPENDIX A

# ACRONYMS

| | |
|---|---|
| BERT | Bit Error Rate Tester |
| bps | bits per second |
| dibit | Two Consecutive Bits |
| HF | High Frequency |
| Hz | Hertz |
| ms | milliseconds |
| PN | Pseudo-random Numerical |
| PSK | Phase Shift Keying |
| Sec | Seconds |
| STANAG | Standardization Agreement |
| tribit | Three Consecutive Bits |
| UUT | Unit Under Test |

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**APPENDIX B**

**STANAG 4529 REQUIREMENTS MATRIX**

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## Table B-1.  STANAG 4529 Requirements Matrix

| Reference Number | STANAG Paragraph | Requirements |
|---|---|---|
| 1 | 1a | This document describes the modulation, call establishment processes, and data correction required to insure interoperability between modems transmitting data over HF radio links where the data rate at the digital interface may be 75,150, 300, 600, or 1200 bps.  The rate at which data (user data bits plus bits for error correction coding) are transmitted (i.e., the channel data rate) may be a 600 bps (when the user data rate is 75, 150, or 300 bps), 1200 bps (when the user data rate is 600 bps), or 1800 bps (when the user data rate is 1200 bps). |
| 2 | 1b | The equipment may also be used for uncoded data transmission in which data input to a modulator's digital interface is transmitted without the addition of the error correction coding and interleaving described in paragraph 10.  The uncoded modes provide data rates of 600, 1200, and 1800 bps. |
| 3 | 2a | The modulation technique consists of phase shifting of a subcarrier frequency that is selectable in 100-Hz steps from 800 to 2400 Hz inclusive. |
| 4 | 2b | Modulation speed is 1200 bauds with a minimum accuracy of 1 part in $10^5$. The accuracy of the clock linked with the generation of the subcarrier frequency is 1 part in $10^5$. |
| 5 | 2c | The phase shift of the modulated signal relative to the unmodulated reference subcarrier may take one of the following values. (see figure A-1).<br><br>Symbol Number      Phase<br>0        0<br>1        $\pi/4$<br>2        $\pi/2$<br>3        $3\pi/4$<br>4        $\pi$<br>5        $5\pi/4$<br>6        $3\pi/2$<br>7        $7\pi/4$<br>The complex number $\exp[jn\pi/2]$ is linked with the symbol number n. |
| 6 | 3a | For the 600 bps channel data rate (75, 150, and 300 bps user data rates), transcoding is achieved by linking one symbol to one bit according to the following rule:<br>Bit      Symbol<br>0        0<br>1        4 |
| 7 | 3b | For the 1200 bps channels data rate (600 bps user data rate), transcoding is achieved by linking one symbol to a set of two consecutive bits (dibit) according to the following rule:<br>Dibit      Symbol<br>00        0<br>01        2<br>11        4<br>10        6<br>↑<br>Most recent bit |

| Reference Number | STANAG Paragraph | Requirements | Subtest Number |
|---|---|---|---|
| 8 | 3c | For the 1800 bps channel data rate (1200 bps user data rate), transcoding is achieved by linking one symbol to a set of three consecutive bits (tribit) according to the following rule:<br><br>Tribit       Symbol<br>000          1<br>001          0<br>010          2<br>011          3<br>100          6<br>101          7<br>110          5<br>111          4<br>↑<br>Most recent bit |  |
| 9 | 4 | The power spectral density of the modulated signal shall be centered on a frequency that is selectable in 100 Hz to 2400 Hz inclusive, with a default value of 1700 Hz. |  |
| 10 | 4 | Filtering shall be applied as necessary so that 99% of the output power is within 1240 Hz. |  |
| 11 | 5 | The symbols to be transmitted are structured in recurrent frames 213.3 ms is length.  A frame consists of 256 symbols. A frame can be broken down into: 80 symbols for synchronization, 48 reference symbols, and 128 data symbols. The 176 reference and data symbols are scrambled by a scrambling sequence with eight-phase-states of length 176.  The reference and data symbols are formed into 4 blocks:  the first 3 consist of 32 data symbols followed by 16 reference symbols:  the last block consists of 32 symbols.  The reference symbols area all symbol number 0. |  |
| 12 | 6 | The synchronization consists of 80 symbols and is transmitted recurrently every 213.3 ms. This sequence uses 2-PSK modulation and the modulation rate is equal to 1200 bauds.  The sequence is identical to a pseudo random sequence of length 31, which is repeated periodically within the 80 symbol window, i.e., the synchronization sequence consists of 2 periods of length 31 plus the first 18 symbols of another period.  A generator for the synchronization sequence is described in figure A-4.  The generator polynomial is:  $x^5 + x^2 + 1$.<br>At the beginning of every frame the generator is initially set to the following value:  11010.  The first symbol of the synchronization sequence is identical to the least significant bit of this initial value.  The remaining 79 symbols are obtained by applying the clock 79 times. |  |

**Table B-1.  STANAG 4529 Requirements Matrix (continued)**

| Reference Number | STANAG Paragraph | Requirements | Subtest Number |
|---|---|---|---|
| 13 | 7 | The scrambling sequence is composed of 176 symbols and is repeated every 213.3 ms. This sequence is transmitted in eight-phase-state modulation at the rate of 1200 bauds.  Data scrambling by an eight-phase-state sequence is done to maintain commonality with STANAG 4285 implementations.<br>The scrambling signal generator is shown in figure A-5.  The symbols are formed by means of a pseudo-random code of length 511, the generator polynomial of which is:  $x^9 + x^4 + 1$.  The generator is initialized to 1 at the start of each frame. A symbol is derived from the triplet consisting of the last three bits in the PN register, i.e., $x_0$ x1 x2  by the following relationship:<br>Scrambling symbol $B_k$ = exp[$jn\pi/4$]<br>Where:<br>$n = 4x_2 + 2x_1 + x_0$<br><br>$x_0$ = 0 or 1<br><br>$x_1$ = 0 or 1<br><br>$x_2$ = 0 or 1<br>Generation from one symbol to the next is by successive shifting of the PN register by three positions. | |
| 14 | 8 | The scrambling operation is carried out on reference and data symbols only, not on the synchronization sequence.  This operation consists of module 8 addition of the data symbol number to the scrambling symbol number; this amounts to complex multiplication of the data symbol by the scrambling symbol. | |
| 15 | 9 | The modem must be capable of tolerating a frequency error of ±37.5 Hz between the transmission and reception of HF carriers (transmitter/receiver frequency error and Doppler shift included) and rate of frequency change of up to 3.5 Hz/sec. | |

## Table B-1.  STANAG 4529 Requirements Matrix (continued)

| Reference Number | STANAG Paragraph | Requirements |
|---|---|---|
| 16 | 10 | For the error correction modes defined in this STANAG, the error correction coding used shall be the rate ½, constraint length 7 convolutional coding as described STANAG 4285, annex E.  For each user data rate described in this STANAG (i.e., 75, 150, 300, 600, and 1200 bps) the coding, interleaving, and flush bits shall be as described for the higher data rate in STANAG 4285, annex E.  The changes necessary to allow 1240 Hz operation are explicitly shown below:<br>The error correction coding used shall be as in STANAG 4285, annex E, section 2 with the following changes:<br>The interleaving shall be as described in STANAG 4285, annex E, section 3 with the following different parameters:<br><br>Number of rows: I = 32 for all data rates<br><br>Delay increment "j" for each successive row:<br><br>      Total Interleaving Delay<br><br>Data rates    20.48 sec  1.706 sec<br>1200 bps     48     4<br>600 bps      24     2<br>300, 150, and 75 bps 12     1<br>Interleaver synchronization shall be as described in STANAG 4285, annex E, part 4 with no changes.  The initialization and message protocol for use with coding and interleaving shall be as described in STANAG 4285, annex E, part 5 with the following difference:<br>The number of flush zeros for each of the data rates and the two interleaver lengths are as follows:<br><br>      Interleaver Delay<br><br>Data rate   20.48 sec   1.706 sec<br>1200 bps   24678    2150<br>600 bps    12390    1126<br>300 bps    6246     614<br>150 bps    3174     358<br>75 bps     1638     230 |

**Table B-1.  STANAG 4529 Requirements Matrix (continued)**

| Reference Number | STANAG Paragraph | Requirements |
|---|---|---|
| 17 | 11 | Modems shall provide uncoded data transmission modes, in which the coding, interleaving, and associated initialization and message protocols (described in section 10) are not applied to the data transmitted. Uncoded data modes shall retain all other characteristics described In this STANAG.  Uncoded data rates of 600, 1200, and 1800 bps shall be provided. |
| **Legend:**  bps – bits per second; HF – High Frequency; Hz – hertz; ms—millisecond; sec—second; PN—Pseudo-random Numerical; PSK—Phase Shift Keying; STANAG – Standardization Agreement |||

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**APPENDIX C**

**DATA COLLECTION FORMS**

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| Form Number | Serial Number | Equipment Nomenclature | Call Sign | Remarks |
|---|---|---|---|---|
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**STANAG 4529**
**CONFORMANCE TEST**
**Event Log Form**

CONTROL NUMBER:

DATE:
(DD/MM/YY)

DATA ENTRY TECHNICIAN:

TEST DIRECTOR:

SIGNATURE:

SIGNATURE:

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| STANAG 4529<br>CONFORMANCE TEST<br>Equipment Configuration Diagram Form | CONTROL NUMBER: |
|---|---|
| | DATE:<br>(DD/MM/YY) |

| | |
|---|---|
| DATA ENTRY TECHNICIAN: | TEST DIRECTOR: |
| SIGNATURE: | SIGNATURE: |

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| | STANAG 4529<br>CONFORMANCE TEST<br>Event Log Form | CONTROL NUMBER: |
|---|---|---|
| | | DATE:<br>(DD/MM/YY) |

| Time (Local) | Initials | Event |
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| TEST TECHNICIAN: | |
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| DATA ENTRY TECHNICIAN: | TEST DIRECTOR: |

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| STANAG 4529<br>**Waveform Conformance**<br>**Test Plan Form** | CONTROL NUMBER: |
|---|---|
| | DATE:<br>(DD/MM/YY) |

| Equipment: | Serial Number: |
|---|---|

Description:

| Remarks |
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| TEST TECHNICIAN: | |
|---|---|
| DATA ENTRY TECHNICIAN: | TEST DIRECTOR: |

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| STANAG 4529 CONFORMANCE TEST Additional Remarks Form | CONTROL NUMBER: |
|---|---|
| | DATE: (DD/MM/YY) |

| Remarks |
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| TEST TECHNICIAN: | |
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| DATA ENTRY TECHNICIAN: | TEST DIRECTOR: |

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**APPENDIX D**

**STANAG 4529 CONFORMANCE TEST PROCEDURES
RESULTS MATRIX**

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## Table D-1.  STANAG 4529 Conformance Test Procedures Results Matrix

| STANAG Paragraph | Requirements | Findings | |
|---|---|---|---|
| | | **Met** | **Not Met** |
| 1a | This document describes the modulation, call establishment process, and data correction required to ensure interoperability between modems transmitting data over HF radio links where the data rate at the digital interface may be 75,150, 300, 600, or 1200 bps.  The rate at which data (user data bits plus bits for error correction coding) is transmitted (i.e., the channel data rate) may be a 600 bps (when the user data rate is 75, 150, or 300 bps), 1200 bps (when the user data rate is 600 bps), or 1800 bps (when the user data rate is 1200 bps). | | |
| 1b | The equipment may also be used for uncoded data transmission in which data input to a modulator's digital interface is transmitted without the addition of the error correction coding and interleaving described in paragraph 10.  The uncoded modes provide data rates of 600, 1200, and 1800 bps. | | |
| 2a | The modulation technique consists of phase shifting of a subcarrier frequency that is selectable in 100-Hz steps from 800 to 2400 Hz inclusive. | | |
| 2b | Modulation speed is 1200 bauds with a minimum accuracy of 1 part in $10^5$.  The accuracy of the clock linked with the generation of the subcarrier frequency is 1 part in $10^5$. | | |
| 2c | The phase shift of the modulated signal relative to the unmodulated reference subcarrier may take one of the following values. (see figure A-1).<br><br>Symbol Number     Phase<br>0                0<br>1                $\pi/4$<br>2                $\pi/2$<br>3                $3\pi/4$<br>4                $\pi$<br>5                $5\pi/4$<br>6                $3\pi/2$<br>7                $7\pi/4$<br>The complex number $\exp[jn\pi/2]$ is linked with the symbol number n. | | |
| 3a | For the 600 bps channel data rate (75, 150, and 300 bps user data rates), transcoding is achieved by linking one symbol to one bit according to the following rule:<br><br>Bit          Symbol<br>0              0<br>1              4 | | |
| 3b | For the 1200 bps channels data rate (600 bps user data rate), transcoding is achieved by linking one symbol to a set of two consecutive bits (dibit) according to the following rule:<br><br>Dibit       Symbol<br>00          0<br>01          2<br>11          4<br>10          6<br>  ↑<br>Most recent bit | | |

| STANAG Paragraph | Requirements | Findings | |
|---|---|---|---|
| | | Met | Not Met |
| 3c | For the 1800 bps channel data rate (1200 bps user data rate), transcoding is achieved by linking one symbol to a set of three consecutive bits (tribit) according to the following rule:<br><br>      Tribit        Symbol<br>      000           1<br>      001           0<br>      010           2<br>      011           3<br>      100           6<br>      101           7<br>      110           5<br>      111           4<br>      ↑<br>    Most recent bit | | |
| 4 | -  The power spectral density of the modulated signal shall be centered on a frequency that is selectable in 100 Hz to 2400 Hz inclusive, with a default value of 1700 Hz. | | |
| 4 | -  Filtering shall be applied as necessary so that 99% of the output power is within 1240 Hz. | | |
| 5a | The symbols to be transmitted are structured in recurrent frames 213.3 ms is length. | | |
| 5b | A frame consists of 256 symbols. A frame can be broken down into: 80 symbols for synchronization, 48 reference symbols, and 128 data symbols. | | |
| 5c | The 176 reference and data symbols are scrambled by a scrambling sequence with eight-phase-states of length 176. | | |
| 5e | The reference and data symbols are formed into 4 blocks:  the first 3 consist of 32 data symbols followed by 16 reference symbols:  the last block consists of 32 symbols.  The reference symbols area all symbol number 0. | | |
| 6a | The synchronization consists of 80 symbols and is transmitted recurrently every 213.3 ms. This sequence uses 2-PSK modulation and the modulation rate is equal to 1200 bauds. | | |
| 6b | The sequence is identical to a pseudo random sequence of length 31, which is repeated periodically within the 80 symbol window, i.e., the synchronization sequence consists of 2 periods of length 31 plus the first 18 symbols of another period. | | |
| 6c | A generator for the synchronization sequence is described in figure A-4.  The generator polynomial is:  $x^5 + x^2 + 1$. | | |
| 6d | At the beginning of every frame the generator is initially set to the following value: 11010. | | |
| 6e | The first symbol of the synchronization sequence is identical to the least significant bit of this initial value.  The remaining 79 symbols are obtained by applying the clock 79 times. | | |

## Table D-1.  STANAG 4529 Conformance Test Procedures Results Matrix (continued)

| STANAG Paragraph | Requirements | Findings | |
|---|---|---|---|
| | | Met | Not Met |
| 7a | The scrambling sequence is composed of 176 symbols and is repeated every 213.3 ms. This sequence is transmitted in eight-phase-state modulation at the rate of 1200 bauds. | | |
| 7b | Data scrambling by an eight-phase-state sequence is done to maintain commonality with STANAG 4285 implementations. | | |
| 7c | The scrambling signal generator is shown in figure A-5.  The symbols are formed by means of a pseudo-random code of length 511, the generator polynomial of which is: $x^9 + x^4 + 1$. | | |
| 7d | The generator is initialized to 1 at the start of each frame. | | |
| 7e | A symbol is derived from the triplet consisting of the last three bits in the PN register, i.e., $x_0$ x1 x2  by the following relationship:<br>Scrambling symbol $B_k$ = exp[jn$\pi$/4]<br>Where:<br>$n = 4x_2 + 2x_1 + x_0$<br><br>$x_0$ = 0 or 1<br><br>$x_1$ = 0 or 1<br><br>$x_2$ = 0 or 1 | | |
| 7f | Generation from one symbol to the next is by successive shifting of the PN register by three positions. | | |
| 8 | The scrambling operation is carried out on reference and data symbols only, not on the synchronization sequence.  This operation consists of module 8 addition of the data symbol number to the scrambling symbol number; this amounts to complex multiplication of the data symbol by the scrambling symbol. | | |
| 9 | The modem must be capable of tolerating a frequency error of +/-37.5 Hz between the transmission and reception of HF carriers (transmitter/receiver frequency error and Doppler shift included) and rate of frequency change of up to 3.5 Hz/sec. | | |
| 10 | For the error correction modes defined in this STANAG, the error correction coding used shall be the rate ½, constraint length 7 convolutional coding as described STANAG 4285, annex E. | | |
| 10 | For each user data rate described in this STANAG (i.e., 75, 150, 300, 600, and 1200 bps) the coding, interleaving, and flush bits shall be as described for the higher data rate in STANAG 4285, annex E.  The changes necessary to allow 1240 Hz operation are explicitly shown below: | | |
| 10a | The error correction coding used shall be as in STANAG 4285, annex E, section 2 with the following changes: | | |

## Table D-1.  STANAG 4529 Conformance Test Procedures Results Matrix
## (continued)

| STANAG Paragraph | Requirements | Findings | |
|---|---|---|---|
| | | Met | Not Met |
| 10b | The interleaving shall be as described in STANAG 4285, annex E, section 3 with the following different parameters:<br><br>Number of rows: I = 32 for all data rates<br><br>Delay increment "j" for each successive row:<br><br>Total Interleaving Delay:<br><br>Data rates     20.48 sec     1.706 sec<br>1200 bps        48          4<br>600 bps         24          2<br>300, 150 and 75 bps  12          1 | | |
| 10c | Interleaver synchronization shall be as described in STANAG 4285, annex E, part 4 with no changes. | | |
| 10d | The initialization and message protocol for use with coding and interleaving shall be as described in STANAG 4285, annex E, part 5 with the following difference:<br>The number of flush zeros for each of the data rates and the two interleaver lengths are as follows:<br><br>Interleaver Delay<br><br>Data rate     20.48 sec     1.706 sec<br>1200 bps     24678       2150<br>600 bps      12390       1126<br>300 bps       6246        614<br>150 bps       3174        358<br>75 bps        1638        230 | | |
| 11 | -  Modems shall provide uncoded data transmission modes, in which the coding, interleaving, and associated initialization and message protocols (described in section 10) are not applied to the data transmitted. | | |
| 11 | -  Uncoded data modes shall retain all other characteristics described in this STANAG. | | |
| 11 | -  Uncoded data rates of 600, 1200, and 1800 bps shall be provided. | | |

**Legend:**  bps – bits per second; HF – High Frequency; Hz – hertz; ms—millisecond; PSK—Phase Shift Keying; PN—Pseudo-random Numerical; sec—second; STANAG – Standardization Agreement

**APPENDIX E**

**REFERENCES**

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# APPENDIX E

## REFERENCES

**E-1**    STANAG 4285, Characteristics of 1200/2400/3600 Bits per Second Single Tone Modulators/Demodulators for HF Radio Links, 16 February 1989

**E-2**    STANAG 4203, Technical Standards for Single Channel HF Radio Equipment, 31 May 1988

**E-3**    STANAG 4481, Minimum Technical Equipment Standards for Naval HF Shore-to-Ship Broadcast Systems, 18 March 1993