AMENDMENT No. 82

TO THE

INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

ANNEX 10

TO THE CONVENTION ON INTERNATIONAL CIVIL AVIATION

VOLUME I

(RADIO NAVIGATION AIDS)

The amendment to Annex 10, Volume I, contained in this document was adopted by the Council of ICAO on **26 February 2007**. Such parts of this amendment as have not been disapproved by more than half of the total number of Contracting States on or before **16 July 2007** will become effective on that date and will become applicable on **22 November 2007** as specified in the Resolution of Adoption. (State letter AN 7/1.1.42 – 07/13 refers.)

FEBRUARY 2007

INTERNATIONAL CIVIL AVIATION ORGANIZATION

AMENDMENT 82 TO THE INTERNATIONAL STANDARDS AND RECOMMENDED PRACTICES

AERONAUTICAL TELECOMMUNICATIONS

RESOLUTION OF ADOPTION

The Council

Acting in accordance with the Convention on International Civil Aviation, and particularly with the provisions of Articles 37, 54 and 90 thereof,

1. *Hereby adopts* on 26 February 2007 Amendment 82 to the International Standards and Recommended Practices contained in the document entitled *International Standards and Recommended Practices, Aeronautical Telecommunications* which for convenience is designated Annex 10 to the Convention;

2. *Prescribes* 16 July 2007 as the date upon which the said amendment shall become effective, except for any part thereof in respect of which a majority of the Contracting States have registered their disapproval with the Council before that date;

3. *Resolves* that the said amendment or such parts thereof as have become effective shall become applicable on 22 November 2007;

4. *Requests the Secretary General*:

   a) to notify each Contracting State immediately of the above action and immediately after 16 July 2007 of those parts of the amendment which have become effective;

   b) to request each Contracting State:

      1) to notify the Organization (in accordance with the obligation imposed by Article 38 of the Convention) of the differences that will exist on 22 November 2007 between its national regulations or practices and the provisions of the Standards in the Annex as hereby amended, such notification to be made before 22 October 2007, and thereafter to notify the Organization of any further differences that arise;

      2) to notify the Organization before 22 October 2007 of the date or dates by which it will have complied with the provisions of the Standards in the Annex as hereby amended;

   c) to invite each Contracting State to notify additionally any differences between its own practices and those established by the Recommended Practices, when the notification of such differences is important for the safety of air navigation, following the procedure specified in subparagraph b) above with respect to differences from Standards.

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equipment on board. In the case when a removable transponder is shared by several light aviation aircraft such as balloons or gliders, it shall be possible to assign a unique address to the removable transponder. The registers 08_{16}, 20_{16}, 21_{16}, 22_{16} and 25_{16} of the removable transponder shall be correctly updated each time the removable transponder is installed in any aircraft;

. . .

Insert new Chapter 12 as follows:

CHAPTER 12. UNIVERSAL ACCESS TRANSCEIVER (UAT)

12.1 DEFINITIONS AND OVERALL SYSTEM CHARACTERISTICS

12.1.1 Definitions

High performance receiver. A UAT receiver with enhanced selectivity to further improve the rejection of adjacent frequency DME interference (see Section 12.3.2.2 for further details).

Optimum sampling point. The optimum sampling point of a received UAT bit stream is at the nominal centre of each bit period, when the frequency offset is either plus or minus 312.5 kHz.

Power measurement point (PMP). A cable connects the antenna to the UAT equipment. The PMP is the end of that cable that attaches to the antenna. All power measurements are considered as being made at the PMP unless otherwise specified. The cable connecting the UAT equipment to the antenna is assumed to have 3 dB of loss.

Pseudorandom message data block. Several UAT requirements state that performance will be tested using pseudorandom message data blocks. Pseudorandom message data blocks should have statistical properties that are nearly indistinguishable from those of a true random selection of bits. For instance, each bit should have (nearly) equal probability of being a ONE or a ZERO, independent of its neighbouring bits. There should be a large number of such pseudorandom message data blocks for each message type (Basic ADS-B, Long ADS-B or Ground Uplink) to provide sufficient independent data for statistical performance measurements. See Section 2.3 of Part I of the *Manual on the Universal Access Transceiver (UAT)* (Doc 9861) for an example of how to provide suitable pseudorandom message data blocks.

Service volume. A part of the facility coverage where the facility provides a particular service in accordance with relevant SARPs and within which the facility is afforded frequency protection.

Standard receiver. A general purpose UAT receiver satisfying the minimum rejection requirements of interference from adjacent frequency distance measuring equipment (DME) (see Section 12.3.2.2 for further details).

Successful message reception (SMR). The function within the UAT receiver for declaring a received message as valid for passing to an application that uses received UAT messages. See Section 4 of Part I of the *Manual on the Universal Access Transceiver (UAT)* (Doc 9861) for a detailed description of the procedure to be used by the UAT receiver for declaring successful message reception.

Universal access transceiver (UAT). A broadcast data link operating on 978 MHz, with a modulation rate of 1.041667 Mbps.

UAT ADS-B message. A message broadcasted once per second by each aircraft to convey state vector and other information. UAT ADS-B messages can be in one of two forms depending on the amount of information to be transmitted in a given second: the *Basic UAT ADS-B Message* or the *Long UAT ADS-B Message* (see Section 12.4.4.1 for definition of each). UAT ground stations can support traffic information service-broadcast (TIS-B) through transmission of individual ADS-B messages in the ADS-B segment of the UAT frame.

UAT ground uplink message. A message broadcasted by ground stations, within the ground segment of the UAT frame, to convey flight information such as text and graphical weather data, advisories, and other aeronautical information, to aircraft that are in the service volume of the ground station (see Section 12.4.4.2 for further details).

12.1.2 UAT Overall System characteristics of aircraft and ground stations

Note.— Details on technical requirements related to the implementation of UAT SARPs are contained in Part I of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861). Part II of the* Manual on the Universal Access Transceiver (UAT*) (Doc 9861) provides additional guidance material.*

12.1.2.1 Transmission frequency

The transmission frequency shall be 978 MHz.

12.1.2.2 Frequency stability

The radio frequency of the UAT equipment shall not vary more than ±0.002 per cent (20 ppm) from the assigned frequency.

12.1.2.3 Transmit power

12.1.2.3.1 Transmit power levels

UAT equipment shall operate at one of the power levels shown in Table 12-1 below.

Table 12-1: Transmitter power levels

Transmitter type	Minimum power at PMP	Maximum power at PMP	Intended minimum air-to-air ranges
Aircraft (Low)	7 watts (+38.5 dBm)	18 watts (+42.5 dBm)	20 NM
Aircraft (Medium)	16 watts (+42 dBm)	40 watts (+46 dBm)	40 NM
Aircraft (High)	100 watts (+50 dBm)	250 watts (+54 dBm)	120 NM
Ground Station	Specified by the service provider to meet local requirements within the constraint of Section 12.1.2.3.2.		

Notes.—

1. *The three levels listed for the avionics are available to support applications with varying range requirements. See the discussion of UAT aircraft Equipage Classes in Section 2.4.2 of Part II of the* Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

2. *The intended minimum air-to-air ranges are for high-density air traffic environments. Larger air-to-air ranges will be achieved in low-density air traffic environments.*

12.1.2.3.2 Maximum power

The maximum EIRP for a UAT aircraft or ground station shall not exceed +58 dBm.

Note.— For example, the maximum EIRP listed above could result from the maximum allowable aircraft transmitter power shown in Table 12-1 with a maximum antenna gain of 4 dBi.

12.1.2.3.3 Transmit mask

The spectrum of a UAT ADS-B message transmission modulated with pseudorandom message data blocks (MDB) shall fall within the limits specified in Table 12-2 when measured in a 100 kHz bandwidth.

Note.— Figure 12-1 is a graphical representation of Table 12-2.

Table 12-2: UAT transmit spectrum

Frequency offset from centre	Required attenuation from maximum power level (dB as measured at the PMP)
All frequencies in the range 0 – 0.5 MHz	0
All frequencies in the range 0.5 – 1.0 MHz	Based on linear* interpolation between these points
1.0 MHz	18
All frequencies in the range 1.0 – 2.25 MHz	Based on linear* interpolation between these points
2.25 MHz	50
All frequencies in the range 2.25 – 3.25 MHz	Based on linear* interpolation between these points
3.25 MHz	60

** based on attenuation in dB and a linear frequency scale*

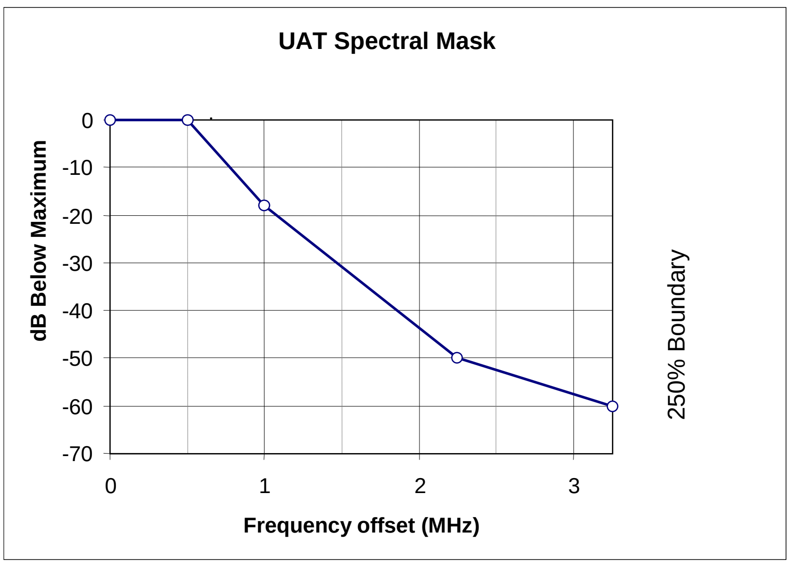

Figure 12-1: UAT transmit spectrum

Notes.—

1. *99 per cent of the power of the UAT spectrum is contained in 1.3 MHz (±0.65 MHz). This is roughly equivalent to the 20 dB bandwidth.*

2. *Spurious emissions requirements begin at ±250 per cent of the 1.3 MHz value, therefore the transmit mask requirement extends to ±3.25 MHz.*

12.1.2.4 Spurious emissions

Spurious emissions shall be kept at the lowest value which the state of the technique and the nature of the service permit.

Note.— Appendix 3 of the ITU Radio Regulations requires that transmitting stations shall conform to the maximum permitted power levels for spurious emissions or for unwanted emissions in the spurious domain.

12.1.2.5 Polarization

The design polarization of emissions shall be vertical.

12.1.2.6 Time/amplitude profile of UAT message transmission

The time/amplitude profile of a UAT message transmission shall meet the following requirements, in which the *reference time* is defined as the beginning of the first bit of the synchronization sequence (see 12.4.4.1.1, 12.4.4.2.1) appearing at the output port of the equipment.

Notes.—

1. *All power requirements for subparagraphs "a" through "f" below apply to the PMP. For installations that support transmitter diversity, the RF power output on the non-selected antenna port should be at least 20 dB below the level on the selected port.*
2. *All power requirements for subparagraphs "a" and "f" assume a 300 kHz measurement bandwidth. All power requirements for subparagraphs "b", "c", "d" and "e" assume a 2 MHz measurement bandwidth.*
3. *The beginning of a bit is 1/2 bit period prior to the optimum sample point.*
4. *These requirements are depicted graphically in Figure12- 2.*

a) Prior to 8 bit periods before the reference time, the RF output power at the PMP shall not exceed –80 dBm.

Note.— This unwanted radiated power restriction is necessary to ensure that the UAT transmitting subsystem does not prevent closely located UAT receiving equipment on the same aircraft from meeting its requirements. It assumes that the isolation between transmitter and receiver equipment at the PMP exceeds 20 dB.

b) Between 8 and 6 bit periods prior to the reference time, the RF output power at the PMP shall remain at least 20 dB below the minimum power requirement for the UAT equipment class.

Note.— Guidance on definition of UAT equipment classes is provided in Part II of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

c) During the Active state, defined as beginning at the reference time and continuing for the duration of the message, the RF output power at the PMP shall be greater than or equal to the minimum power requirement for the UAT equipment class.

d) The RF output power at the PMP shall not exceed the maximum power for the UAT equipment class at any time during the Active state.

e) Within 6 bit periods after the end of the Active state, the RF output power at the PMP shall be at a level at least 20 dB below the minimum power requirement for the UAT equipment class.

f) Within 8 bit periods after the end of the Active state, the RF output power at the PMP shall fall to a level not to exceed –80 dBm.

Note.— This unwanted radiated power restriction is necessary to ensure that the transmitting subsystem does not prevent closely located UAT receiving equipment on the same aircraft from meeting its requirements. It assumes that the isolation between transmitter and receiver equipment at the PMP exceeds 20 dB.

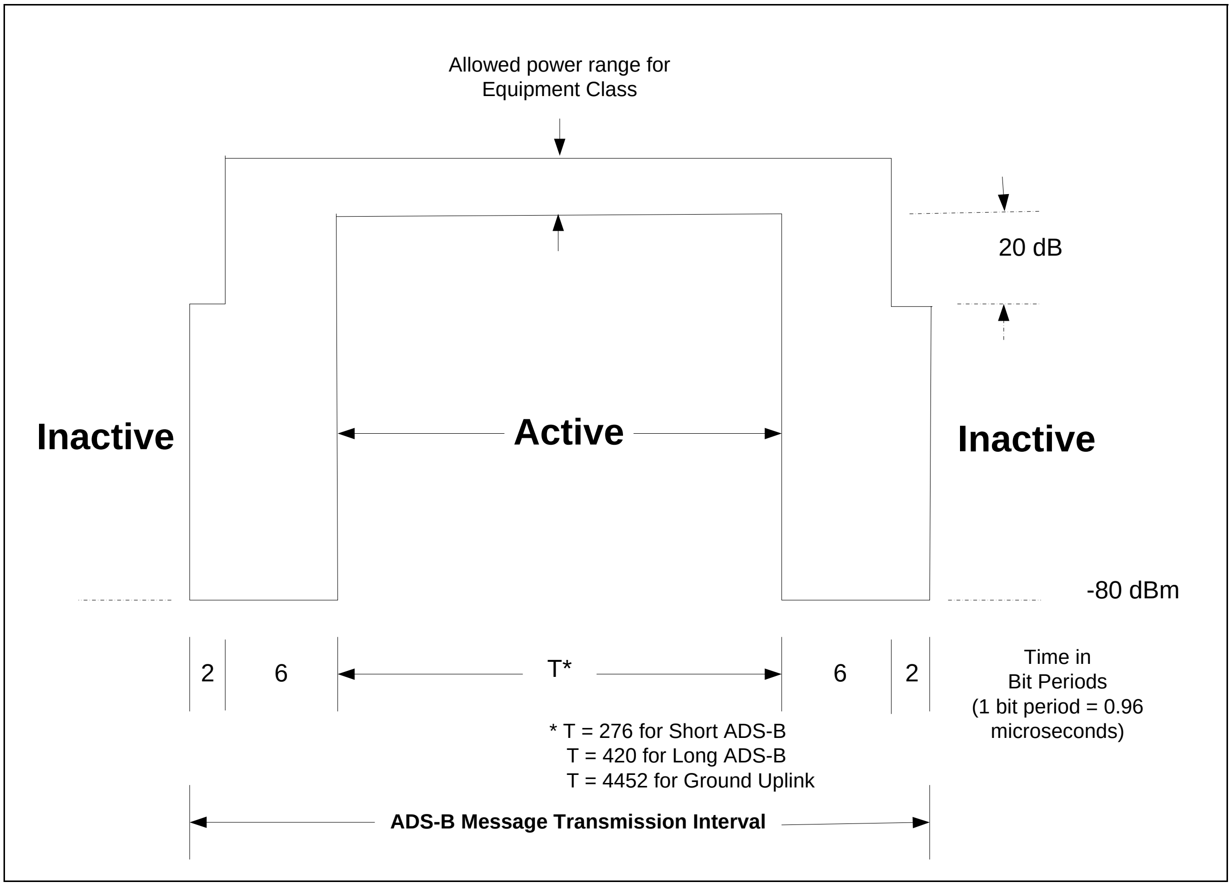

Figure 12-2: Time/amplitude profile of UAT message transmission

12.1.3 Mandatory carriage requirements

Requirements for mandatory carriage of UAT equipment shall be made on the basis of regional air navigation agreements which specify the airspace of operation and the implementation timescales for the carriage of equipment, including the appropriate lead time.

Note.— No changes will be required to aircraft systems or ground systems operating solely in regions not using UAT.

12.2 SYSTEM CHARACTERISTICS OF THE GROUND INSTALLATION

12.2.1 Ground station transmitting function

12.2.1.1 Ground station transmitter power

12.2.1.1.1 **Recommendation.**— *The effective radiated power should be such as to provide a field strength of at least 280 microvolts per metre (minus 97 dBW/m^2) within the service volume of the facility on the basis of free-space propagation.*

Note.— This is determined on the basis of delivering a –91 dBm (corresponds to 200 microvolts per metre) signal level at the PMP (assuming an omnidirectional antenna). The 280 µV/m recommendation corresponds to the delivery of a –88 dBm signal level at the PMP of the receiving equipment. The 3 dB difference between –88 dBm and –91 dBm provides margin for excess path loss over free-space propagation.

12.2.2 Ground station receiving function

Note.— An example ground station receiver is discussed in Section 2.5 of Part II of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861), with UAT air-to-ground performance estimates consistent with use of that receiver provided in Appendix B of that manual.*

12.3 SYSTEM CHARACTERISTICS OF THE AIRCRAFT INSTALLATION

12.3.1 Aircraft transmitting function

12.3.1.1 Aircraft Transmitter Power

The effective radiated power shall be such as to provide a field strength of at least 225 microvolts per metre (minus 99 dBW/m^2) on the basis of free-space propagation, at ranges and altitudes appropriate to the operational conditions pertaining to the areas over which the aircraft is operated. Transmitter power shall not exceed 54 dBm at the PMP.

Notes.—

1. *The above field strength is determined on the basis of delivering a –93 dBm (corresponds to 160 microvolts per metre) signal level at the PMP (assuming an omnidirectional antenna). The 3 dB difference between 225 µV/m and 160 µV/m provides margin for excess path loss over free-space propagation when receiving a Long UAT ADS-B Message. A 4 dB margin is provided when receiving a Basic UAT ADS-B Message.*
2. *Various aircraft operations may have different air-air range requirements depending on the intended ADS-B function of the UAT equipment. Therefore different installations may operate at different power levels (see Section 12.1.2.3.1).*

12.3.2 Receiving function

12.3.2.1 Receiver sensitivity

12.3.2.1.1 Long UAT ADS-B message as desired signal

A desired signal level of –93 dBm applied at the PMP shall produce a rate of successful message reception (SMR) of 90 per cent or better under the following conditions:

a) When the desired signal is of nominal modulation (i.e. FM deviation is 625 kHz) and at the maximum signal frequency offsets, and subject to relative Doppler shift at ±1 200 knots.

b) When the desired signal is of maximum modulation distortion allowed in Section 12.4.3, at the nominal transmission frequency ±1 parts per million (ppm), and subject to relative Doppler shift at ±1 200 knots.

Note.— The receiver criteria for successful message reception of UAT ADS-B messages are provided in Section 4 of Part I of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

12.3.2.1.2 Basic UAT ADS-B message as desired signal

A desired signal level of –94 dBm applied at the PMP shall produce a rate of an SMR of 90 per cent or better under the following conditions:

a) When the desired signal is of nominal modulation (i.e. FM deviation is 625 kHz) and at the maximum signal frequency offsets, and subject to relative Doppler shift at ±1 200 knots.

b) When the desired signal is of maximum modulation distortion allowed in Section 12.4.3, at the nominal transmission frequency ±1 ppm, and subject to relative Doppler shift at ±1 200 knots.

Note.— The receiver criteria for successful message reception of UAT ADS-B messages are provided in Section 4 of Part I of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

12.3.2.1.3 UAT ground uplink message as desired signal

A desired signal level of –91 dBm applied at the PMP shall produce a rate of an SMR of 90 per cent or better under the following conditions:

a) When the desired signal is of nominal modulation (i.e. FM deviation is 625 kHz) and at the maximum signal frequency offsets, and subject to relative Doppler shift at ±850 knots;

b) When the desired signal is of maximum modulation distortion allowed in Section 12.4.3, at the nominal transmission frequency ±1 ppm, and subject to relative Doppler shift at ±850 knots.

Notes.—

1. *The receiver criteria for successful message reception of UAT ground uplink messages is provided in Section 4 of Part I of the Manual on the Universal Access Transceiver (UAT)* (Doc 9861).
2. *This requirement ensures the bit rate accuracy supporting demodulation in the UAT equipment is adequate to properly receive the longer UAT ground uplink message.*

12.3.2.2 Receiver selectivity

Notes.—

1. *The undesired signal used is an unmodulated carrier applied at the frequency offset.*
2. *This requirement establishes the receiver's rejection of the off-channel energy.*

3. *It is assumed that ratios in between the specified offsets will fall near the interpolated value.*
4. *The desired signal used is a UAT ADS-B long message at –90 dBm at the PMP, to be received with a 90 per cent successful message reception rate.*
5. *The tolerable co-channel continuous wave interference power level for aircraft UAT receivers is assumed to be –101 dBm or less at the PMP.*
6. *See Section 2.4.2 of Part II of the* Manual on the Universal Access Transceiver (UAT) *(Doc 9861) for a discussion of when a high performance receiver is desirable.*

a) Standard receivers shall meet the selectivity characteristics given in Table 12-3:

Table 12-3: Standard receiver rejection ratios

Frequency offset from centre	**Minimum rejection ratio (Undesired/desired level in dB)**
–1.0 MHz	10
+1.0 MHz	15
(±) 2.0 MHz	50
(±) 10.0 MHz	60

Note.— It is assumed that ratios in between the specified offsets will fall near the interpolated value.

b) High performance receivers shall meet the more stringent selectivity characteristics given in Table 12-4:

Table 12-4: High-performance receiver rejection ratios

Frequency offset from centre	**Minimum rejection ratio (Undesired/desired level in dB)**
–1.0 MHz	30
+1.0 MHz	40
(±) 2.0 MHz	50
(±) 10.0 MHz	60

Note.— See Section 2.4.2 of Part II of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861) for guidance material on the implementation of high-performance receivers.*

12.3.2.3 Receiver desired signal dynamic range

The receiver shall achieve a successful message reception rate for long ADS-B messages of 99 per cent or better when the desired signal level is between –90 dBm and –10 dBm at the PMP in the absence of any interfering signals.

Note.— The value of –10 dBm represents 120-foot separation from an aircraft transmitter transmitting at maximum allowed power.

12.3.2.4 Receiver tolerance to pulsed interference

Note.— All power level requirements in this section are referenced to the PMP.

a) For Standard and High Performance receivers the following requirements shall apply:

1. The receiver shall be capable of achieving 99 per cent SMR of Long UAT ADS-B Messages when the desired signal level is between –90 dBm and -10 dBm when subjected to DME interference under the following conditions: DME pulse pairs at a nominal rate of 3 600 pulse pairs per second at either 12 or 30 microseconds pulse spacing at a level of –36 dBm for any 1 MHz DME channel frequency between 980 MHz and 1 213 MHz inclusive.

2. Following a 21 microsecond pulse at a level of ZERO (0) dBm and at a frequency of 1 090 MHz, the receiver shall return to within 3 dB of the specified sensitivity level (see 12.3.2.1) within 12 microseconds.

b) For the standard receiver the following additional requirements shall apply:

1. The receiver shall be capable of achieving 90 per cent SMR of long UAT ADS-B messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME interference under the following conditions: DME pulse pairs at a nominal rate of 3 600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -56 dBm and a frequency of 979 MHz.

2. The receiver shall be capable of achieving 90 per cent SMR of long UAT ADS-B messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME interference under the following conditions: DME pulse pairs at a nominal rate of 3 600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -70 dBm and a frequency of 978 MHz.

c) For the high-performance receiver the following additional requirements shall apply:

1. The receiver shall be capable of achieving 90 per cent SMR of long UAT ADS-B messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME interference under the following conditions: DME pulse pairs at a nominal rate of 3 600 pulse pairs per second at a 12 microseconds pulse spacing at a level of -43 dBm and a frequency of 979 MHz.

2. The receiver shall be capable of achieving 90 per cent SMR of long UAT ADS-B messages when the desired signal level is between -87 dBm and -10 dBm when subjected to DME interference under the following conditions: DME pulse pairs at a nominal rate of 3 600 pulse pairs per second

at a 12 microseconds pulse spacing at a level of -79 dBm and a frequency of 978 MHz.

12.4 PHYSICAL LAYER CHARACTERISTICS

12.4.1 Modulation rate

The modulation rate shall be 1.041667 Mbps with a tolerance for aircraft transmitters of ±20 ppm and a tolerance for ground transmitters of ±2 ppm.

Note.— The tolerance on the modulation rate is consistent with the requirement on modulation distortion (See 12.4.3).

12.4.2 Modulation type

a) Data shall be modulated onto the carrier using binary continuous phase frequency shift keying. The modulation index, *h*, shall be no less than 0.6;

b) A binary ONE (1) shall be indicated by a shift up in frequency from the nominal carrier frequency and a binary ZERO (0) by a shift down from the nominal carrier frequency.

Notes.—

1. *Filtering of the transmitted signal (at base band and/or after frequency modulation) will be required to meet the spectral containment requirement of Section 12.1.2.3.3. This filtering may cause the deviation to exceed these values at points other than the optimum sampling points.*
2. *Because of the filtering of the transmitted signal, the received frequency offset varies continuously between the nominal values of ±312.5 kHz (and beyond), and the optimal sampling point may not be easily identified. This point can be defined in terms of the so-called "eye diagram" of the received signal. The ideal eye diagram is a superposition of samples of the (undistorted) post detection waveform shifted by multiples of the bit period (0.96 microseconds). The optimum sampling point is the point during the bit period at which the opening of the eye diagram (i.e. the minimum separation between positive and negative frequency offsets at very high signal-to-noise ratios) is maximized. An example "eye diagram" can be seen in Figure 12-3. The timing of the points where the lines converge defines the "optimum sampling point." Figure 12-4 shows an eye pattern that has been partially closed by modulation distortion.*

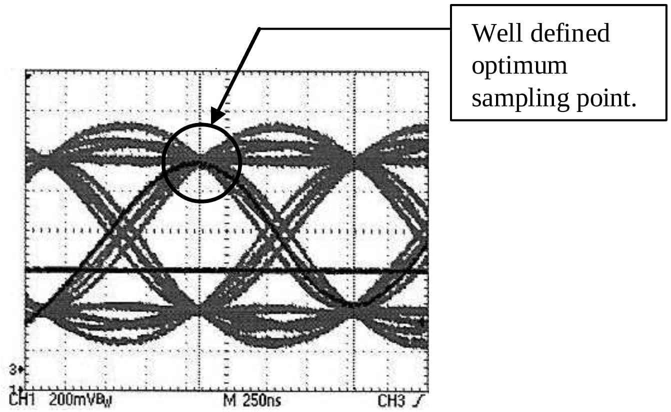

Figure 12-3: Ideal eye diagram

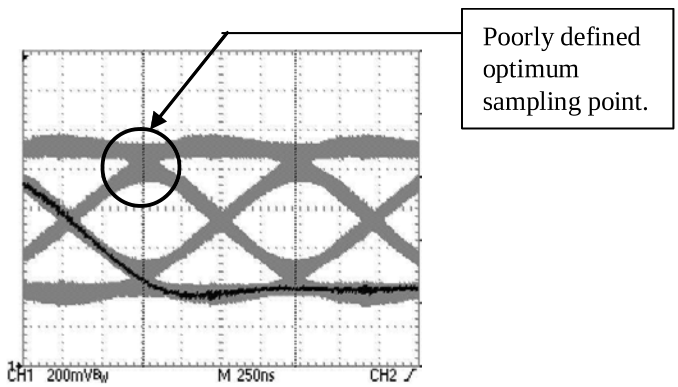

Figure 12-4: Distorted eye diagram

12.4.3 Modulation distortion

a) For aircraft transmitters, the minimum vertical opening of the eye diagram of the transmitted signal (measured at the optimum sampling points) shall be no less than 560 kHz when measured over an entire long UAT ADS-B message containing pseudorandom message data blocks.

b) For ground transmitters, the minimum vertical opening of the eye diagram of the transmitted signal (measured at the optimum sampling points) shall be no less than 560 kHz when measured over an entire UAT ground uplink message containing pseudorandom message data blocks.

c) For aircraft transmitters, the minimum horizontal opening of the eye diagram of the transmitted signal (measured at 978 MHz) shall be no less than 0.624 microseconds (0.65 symbol periods) when measured over an entire long UAT ADS-B message containing pseudorandom message data blocks.

d) For ground transmitters, the minimum horizontal opening of the eye diagram of the transmitted signal (measured at 978 MHz) shall be no less than 0.624 microseconds (0.65 symbol periods) when measured over an entire UAT ground uplink message containing pseudorandom message data blocks.

Notes.—

1. *Section 12.4.4 defines the UAT ADS-B message types.*
2. *The ideal eye diagram is a superposition of samples of the (undistorted) post detection waveform shifted by multiples of the bit period (0.96 microseconds).*

12.4.4 Broadcast message characteristics

The UAT system shall support two different message types: the UAT ADS-B message and the UAT ground uplink message.

12.4.4.1 UAT ADS-B message

The Active portion (see 12.1.2.6) of a UAT ADS-B message shall contain the following elements, in the following order:

- Bit synchronization
- Message data block
- FEC parity.

12.4.4.1.1 Bit synchronization

The first element of the Active portion of the UAT ADS-B message shall be a 36-bit synchronization sequence. For the UAT ADS-B messages the sequence shall be:

111010101100110111011010010011100010

with the left-most bit transmitted first.

12.4.4.1.2 The message data block

The second element of the Active portion of the UAT ADS-B message shall be the message data block. There shall be two lengths of UAT ADS-B message data blocks supported. The basic UAT ADS-B message shall have a 144-bit message data block and the long UAT ADS-B message shall have a 272-bit message data block.

Notes.— The format, encoding and transmission order of the message data block element is provided in Section 2.1 of Part I of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

12.4.4.1.3 FEC parity

The third and final element of the Active portion of the UAT ADS-B message shall be the FEC parity.

12.4.4.1.3.1 Code type

The FEC parity generation shall be based on a systematic Reed-Solomon (RS) 256-ary code with 8-bit code word symbols. FEC parity generation shall be per the following code:

a) **Basic UAT ADS-B Message**: Parity shall be a RS (30, 18) code.

Note.— This results in 12 bytes (code symbols) of parity capable of correcting up to 6 symbol errors per block.

b) **Long UAT ADS-B Message**: Parity shall be a RS (48, 34) code.

Note.— This results in 14 bytes (code symbols) of parity capable of correcting up to 7 symbol errors per block.

For either message length the primitive polynomial of the code shall be as follows:

$$p(x) = x^8 + x^7 + x^2 + x + 1.$$

The generator polynomial shall be as follows:

$$\prod_{i=120}^{P} (x - \alpha^i)$$

where:

P = 131 for RS (30, 18) code,
P = 133 for RS (48, 34) code, and
α is a primitive element of a Galois field of size 256 (i.e. GF(256)).

12.4.4.1.3.2 Transmission order of FEC parity

FEC parity bytes shall be ordered most significant to least significant in terms of the polynomial coefficients they represent. The ordering of bits within each byte shall be most significant to least significant. FEC parity bytes shall follow the message data block.

12.4.4.2 UAT ground uplink message

The Active portion of a UAT ground uplink message shall contain the following elements, in the following order:

- bit synchronization
- interleaved message data block and FEC parity.

12.4.4.2.1 Bit synchronization

The first element of the Active portion of the UAT ground uplink message shall be a 36-bit synchronization sequence. For the UAT ground uplink message the sequence shall be:

000101010011001000100101101100011101

with the left-most bit transmitted first.

12.4.4.2.2 Interleaved message data block and FEC parity

12.4.4.2.2.1 Message data block (before interleaving and after de-interleaving)

The UAT ground uplink message shall have 3 456 bits of message data block. These bits are divided into 6 groups of 576 bits. FEC is applied to each group as described in 12.4.4.2.2.2.

Note.— Further details on the format, encoding and transmission order of the UAT ground uplink message data block are provided in Section 2.2 of Part I of the Manual on the Universal Access Transceiver (UAT) *(Doc 9861).*

12.4.4.2.2.2 FEC parity (before interleaving and after de-interleaving)

12.4.4.2.2.2.1 Code type

The FEC parity generation shall be based on a systematic RS 256-ary code with 8 bit code word symbols. FEC parity generation for each of the six blocks shall be a RS (92,72) code.

Notes.—

1. *Section 12.4.4.2.2.3 provides details on the interleaving procedure.*

2. *This results in 20 bytes (symbols) of parity capable of correcting up to 10 symbol errors per block. The additional use of interleaving for the UAT ground uplink message allows additional robustness against burst errors.*

The primitive polynomial of the code is as follows:

$$p(x) = x^8 + x^7 + x^2 + x + 1.$$

The generator polynomial is as follows:

$$\prod_{i=120}^{P} (x - \alpha^i)$$

where

P = 139, and
α is a primitive element of a Galois field of size 256 (i.e. GF(256)).

12.4.4.2.2.2.2 Transmission order of FEC parity

FEC parity bytes are ordered most significant to least significant in terms of the polynomial coefficients they represent. The ordering of bits within each byte will be most significant to least significant. FEC parity bytes will follow the message data block.

12.4.4.2.2.3 Interleaving procedure

UAT ground uplink messages shall be interleaved and transmitted by the ground station, as listed below:

a) **Interleaving procedure**: The interleaved message data block and FEC parity consists of 6 interleaved Reed-Solomon blocks. The interleaver is represented by a 6x92 matrix, where each entry is a RS 8-bit symbol. Each row comprises a single RS (92,72) block as shown in Table 12-5. In this table, block numbers prior to interleaving are represented as “A” through “F.” The information is ordered for transmission column by column, starting at the upper left corner of the matrix.

Table 12-5: Ground uplink interleaver matrix

RS Block	MDB Byte #						FEC Parity (Block /Byte #)			
A	1	2	3	…	71	72	A/1	…	A/19	A/20
B	73	74	75	…	143	144	B/1	…	B/19	B/20
C	145	146	147	…	215	216	C/1	…	C/19	C/20
D	217	218	219	…	287	288	D/1	…	D/19	D/20
E	289	290	291	…	359	360	E/1	…	E/19	E/20
F	361	362	363	…	431	432	F/1	…	F/19	F/20

Note.— In Table 12-5, message data block Byte #1 through #72 are the 72 bytes (8 bits each) of message data block information carried in the first RS (92,72) block. FEC parity A/1 through A/20 are the 20 bytes of FEC parity associated with that block (A).

b. **Transmission order**: The bytes are then transmitted in the following order:

1,73,145,217,289,361,2,74,146,218,290,362,3,. . .,C/20,D/20,E/20,F/20.

Note.— On reception these bytes need to be de-interleaved so that the RS blocks can be reassembled prior to error correction decoding.

12.5 Guidance material

Notes.—

1. The Manual on the Universal Access Transceiver (UAT) *(Doc 9861)*, Part I, *provides detailed technical specifications on UAT, including ADS-B message data blocks and formats, procedures for operation of UAT transmitting subsystems, and avionics interface requirements with other aircraft systems.*

2. The Manual on the Universal Access Transceiver (UAT) *(Doc 9861)*, Part II, *provides information on UAT system operation, description of a range of example avionics equipment classes and their applications, guidance on UAT aircraft and ground station installation aspects, and detailed information on UAT system performance simulation.*

End of new Chapter 12

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