

ADVANCED TELEVISION TECHNOLOGY CENTER

**Minimum Target Performance Requirements
for Digital Television Broadcast Receivers**

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FORWARD

This document addresses the receiver portion of the digital terrestrial television broadcast system including a steerable directional antenna to be used for indoor applications. The minimum performance requirements originate from a recognition that some digital television (DTV) receivers may not perform such that reliable reception is ensured. The requirements for interference rejection are based upon the FCC planning factors used to determine DTV channel allotments. Tests performed by the Advanced Television Technology Center (ATTC) on commercially available consumer DTV receivers have demonstrated that some receivers fail to meet the FCC planning factors. Other requirements are based upon measured performance achieved by actual receivers. These concerns over receiver performance have led to the development of minimum targets for performance.

1. SCOPE & DOCUMENTATION STRUCTURE

1.1. Scope

This document provides a detailed description of the parameters and characteristics for a Digital Television (DTV) receiver to be used in the over-the-air broadcast environment.

1.2. Documentation structure

The minimum requirements for a digital television broadcast receiver described in this document include a general system overview, a list of reference documents, and target requirements for each portion of the receiver.

2. NORMATIVE REFERENCES

47 CFR Part 73, *FCC Rules*

ATSC A/52A, *Digital Audio Compression (AC-3) Standard (Revision A)*

ATSC A/53B, *ATSC Digital Television Standard (Revision B with Amendment No. 1)*

ATSC A/65A, *Program and System Information Protocol for Terrestrial Broadcast and Cable (Revision A with and Amendments No. 1A, 2, and 3)*

ATSC A/69, *Program and System Information Protocol Implementations Performance guidelines for Broadcasters*

ATTC 01-27, *Digital Television Test Procedures*

EIA/CEA-CEB-5, *Recommended Practice for DTV Receivers*

EIA-708-B, *Digital Television (DTV) Closed Captioning*

EIA/CEA-CEB-10-A, *EIA-708-B Implementation Guidance*

EIA/CEA-775-A, *DTV 1394 Interface Specification*

EIA/CEA-909, *Antenna Control Interface*

JEITA CP-1201, *Digital Audio Interface*

SMPTE 274, *1920x1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates*

SMPTE 296, *1280x720 Scanning, Analog and Digital Representation and Analog Interface*

SMPTE RP160, *Three Channel Parallel Analog Component High-Definition Video Interface*

3. COMPLIANCE NOTATION

As used in this document, “*shall*” or “*will*,” suggests a minimum performance requirement. “*Should*” denotes a provision that is recommended but not mandatory. “*May*” denotes a feature whose presence does not preclude compliance that may or may not be present at the option of the implementer.

4. SYSTEM OVERVIEW

4.1. Objective

The minimum target performance requirements for digital television broadcast receivers describe a system designed to ensure reliable reception of digital television in the terrestrial environment. Since the ATSC A/53B Digital Television Standard specifies only the system up to RF transmission, these requirements provide a basis for the reception portion.

4.2. System block diagram

A basic block diagram representation of the digital terrestrial television system is shown in Figure 1. The video subsystem, the service multiplex and transport, and the RF/transmission system are described in the ATSC A/53B standard. These requirements describe the performance characteristics of the antenna and receiver.

Figure 2 illustrates the antenna subsystem, which includes a steerable directional antenna, programmable preamplifier, and a control interface. The control interface allows the receiver to select the optimum settings for antenna direction and polarization, as well as preamplifier gain.

Figure 3 illustrates the digital television receiver subsystem, which includes the RF tuner, AGC, and equalizer as well as the video and audio outputs.

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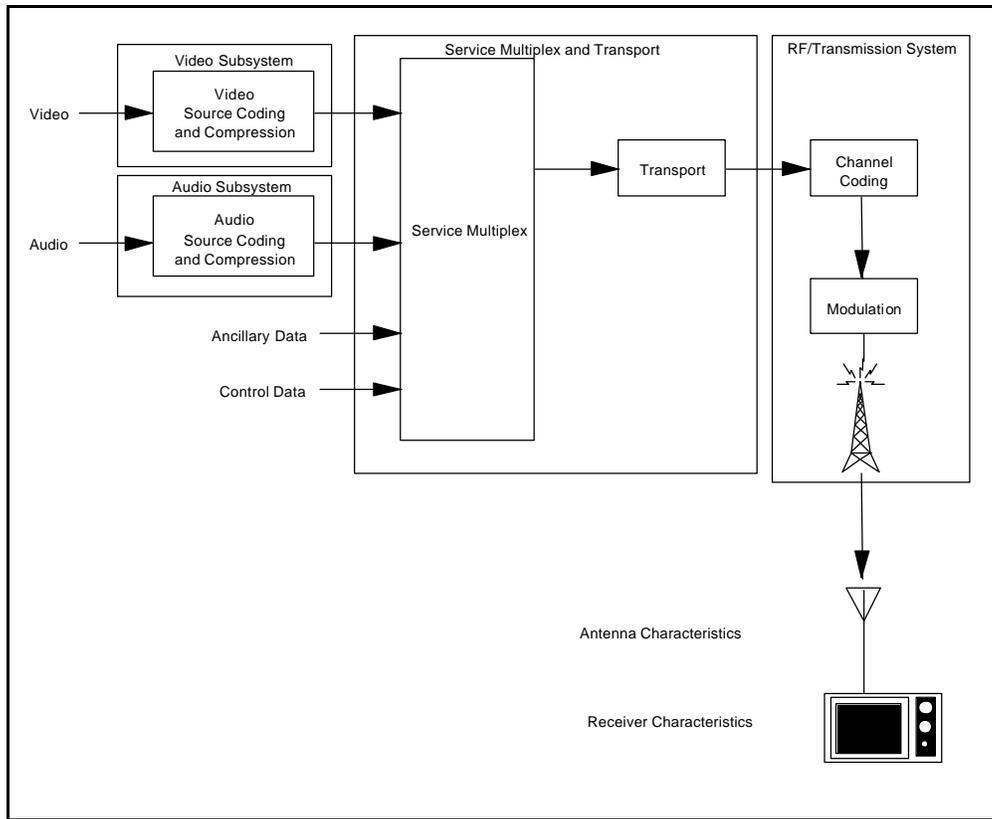


Figure 1 - Digital terrestrial television broadcasting model

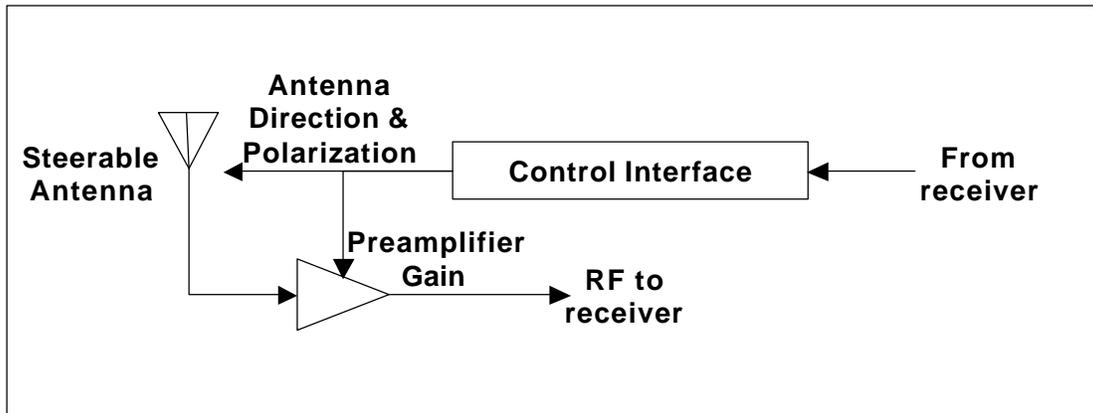


Figure 2 - Digital television antenna subsystem block diagram

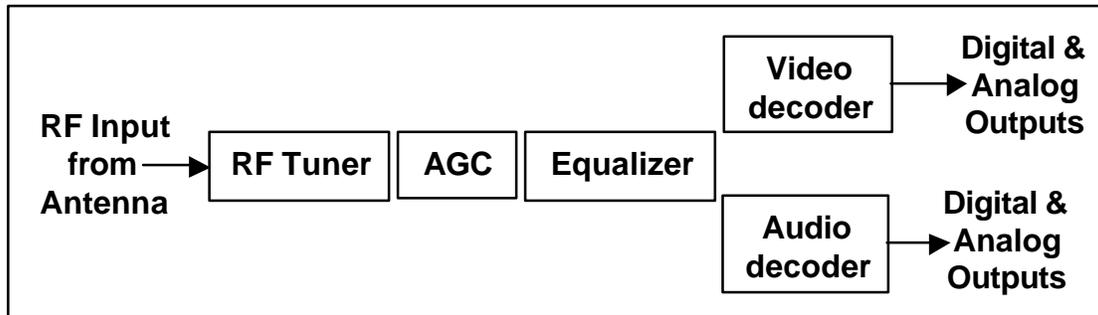


Figure 3 – Digital television receiver subsystem block diagram

5. MINIMUM PERFORMANCE REQUIREMENTS

5.1. RECEIVER CHARACTERISTICS

5.1.1. Antenna Control Interface

The receiver shall have an antenna control interface in accordance with the EIA/CEA-909 standard and shall utilize the interface to optimize performance.

5.1.2. RF Connector

The RF signal input to the DTV receiver shall be a female F-type connector.

5.1.3. Input impedance

The characteristic input impedance of the receiver at the RF signal input shall be 75 ± 10 ohms.

5.1.4. VSWR

The maximum VSWR at the RF signal input of the receiver shall not be greater than 1.15 across any DTV channel.

5.1.5. Noise figure

The receiver Noise Figure shall not exceed 10 dB at VHF and 7 dB at UHF.

5.1.6. RF signal level

5.1.6.1. VHF

The receiver shall operate on VHF channels within the range of input RF signal levels from -81 dBm to -8 dBm. A signal level of $+10$ dBm shall not cause damage to the receiver.

5.1.6.2. UHF

The receiver shall operate on UHF channels within the range of input RF signal levels from -84 dBm to -8 dBm. A signal level of +10 dBm shall not cause damage to the receiver.

5.1.7. Noise performance

The receiver shall have an Additive White Gaussian Noise (AWGN) threshold not to exceed 15.2 dB when receiving a standard 8-VSB signal at -28 dBm. Threshold shall be measured at the Threshold of Visibility (TOV) or at a bit error rate (BER) in the transport stream of 3.0×10^{-6} .

5.1.8. Phase noise performance

The receiver shall operate with pilot phase noise in excess of -70 dBc/Hz at 20 kHz offset.

5.1.9. Channels

Broadcast channelization as specified in the FCC Rules under 47 CFR Part 73 shall be used.

5.1.10. AGC performance

The receiver AGC range shall not be less than 66 dB.

5.1.11. Co-channel rejection

The receiver shall not exceed the following thresholds for rejection of co-channel interference at a desired signal level of -68 dBm:

Table 1 – Co-channel rejection thresholds

Type of Interference	Co-channel D/U ratio (dB)
DTV interference into DTV	+15.3
NTSC interference into DTV	+1.8

5.1.12. Adjacent channel rejection

The receiver shall not exceed the following thresholds for rejection of adjacent-channel interference at a desired signal level of -68 dBm:

Table 2 – Adjacent channel thresholds

Type of Interference	Adjacent channel D/U ratio (dB)
Lower DTV interference into DTV	-42.0
Lower NTSC interference into DTV	-47.7
Upper DTV interference into DTV	-43.2
Upper NTSC interference into DTV	-48.7

5.1.13. Taboo channel rejection

The receiver shall not exceed the following thresholds for rejection of taboo-channel interference at a desired signal level of -68 dBm:

5.1.13.1. DTV interference into DTV

Table 3 – Taboo channel rejection thresholds for DTV interference into DTV

Channel	Taboo channel D/U ratio (dB)
N-2	-60.5
N+2	-59.1
N-3	-60.6
N+3	-61.5
N-4	-58.0
N+4	-62.0
N-7	-63.0
N+7	-63.0
N-8	-63.0
N+8	-63.0
N+14	-63.0
N+15	-63.0

5.1.13.2. NTSC interference into DTV

Table 4 – Taboo channel rejection thresholds for NTSC interference into DTV

Channel	Taboo channel D/U ratio (dB)
N-2	-62.5
N+2	-59.9
N-3	-61.8
N+3	-62.5
N-4	-58.0
N+4	-58.0
N-7	-58.0
N+7	-58.0
N-8	-58.0
N+8	-58.0
N+14	-58.0
N+15	-58.0

5.1.14. Equalizer performance

5.1.14.1. Equalizer Range

The receiver equalizer shall have a range from -20.5 microseconds (pre-echo) to +46.5 microseconds (post-echo).

5.1.14.2. Multipath performance

Single Static Echoes

The receiver shall perform throughout the region illustrated in Figure 5. Performance shall be determined by TOV with a desired DTV signal power of -28 dBm in the presence of AWGN with an SNR of 18 dB and a single echo of -31 dBm with varying delays. The echo phase shall rotate with a 0.05 Hz rate.

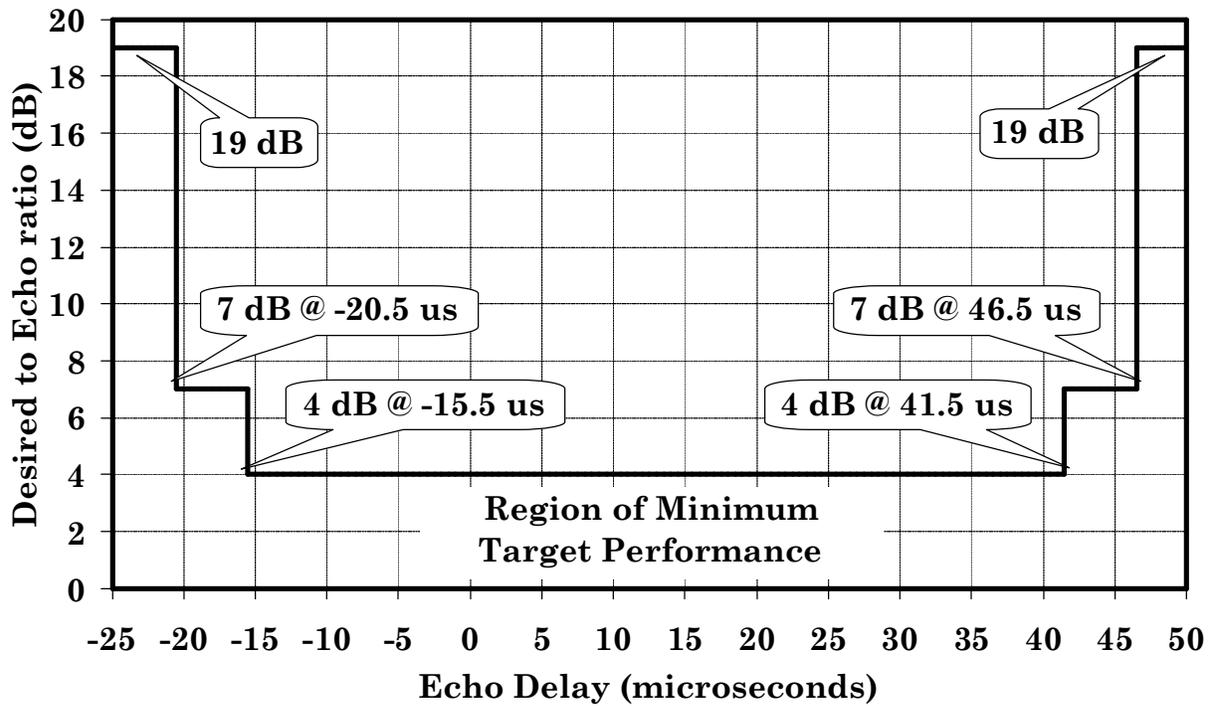


Figure 4 - Region of minimum target performance for a desired DTV signal in the presence of a single static echo of varying delay.

Single Dynamic Echoes at varying Doppler Rates

The receiver shall perform throughout the region illustrated in Figure 5. Performance shall be determined by TOV with a desired DTV signal at -28 dBm in the presence of AWGN with an SNR of 25 dB and a single dynamic echo with Doppler rates from zero to 75 Hz.

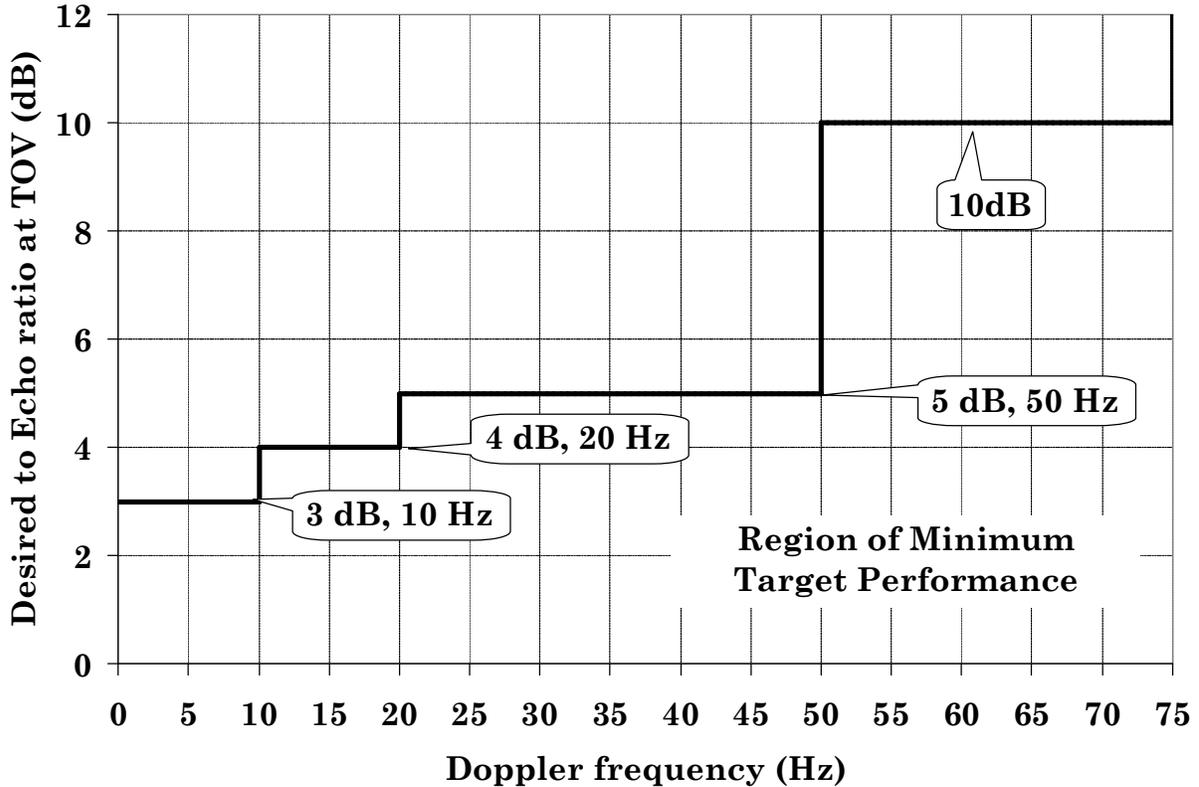


Figure 5 - Region of minimum target performance for a desired DTV signal in the presence of AWGN and a single dynamic echo of varying Doppler.

Echo Ensembles

The receiver shall not exceed the performance thresholds for various echo ensembles as tabulated in Table 5. The “ATTC” ensembles are defined in Table 6 and the “CRC” ensembles are defined in Table 7.

Table 5 – Performance Thresholds for Echo Ensembles

Ensemble Type	Maximum Main to Variable Path Ratio (dB)	Doppler Rate (Hz)
ATTC Dynamic 3	11	0.5 to 100
ATTC Dynamic 4	11	0.5 to 100
CRC #1	4	1 or 5
CRC #2	5	1 or 5
CRC #3	7	1 or 5
CRC #4	22	1 or 5

Table 6 – Multipath Profiles for ATTC Ensembles

ATTC Ensemble	Channel Simulator Parameter	Path 1	Path 2	Path 3	Paths 4, 5, 6
Dynamic 3	Delay (µs)	0	0.4	0.4	N/A
	Attenuation (dB)	0	Variable (see note)	Variable (see note)	OFF
	Phase (degrees)	0	0.05 Hz Doppler	Variable Doppler	N/A
Dynamic 4	Delay (µs)	0	6.5	6.5	N/A
	Attenuation (dB)	0	Variable (see note)	Variable (see note)	OFF
	Phase (degrees)	0	0.05 Hz Doppler	Variable Doppler	N/A

Note: The attenuation of paths 2 and 3 are varied together.

Table 7 – Multipath Profiles for CRC Ensembles

CRC Ensemble	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6	
#1	Relative attenuation (dB)	0	20	20	Varied to reach TOV	18	
#2		0	17	17		7	15
#3		0	14	14		4	12
#4		0	11	11		1	9
Delay (msec)	0	-1.8	0.15	1.8	5.7	35.0	
Phase or Doppler	0	125°	80°	45°	1 or 5 Hz	90°	

5.1.15. Symbol and Transport Rates

The receiver shall operate over the following range of symbol rates and transport rates:

Table 8 – Symbol and transport rates

Parameter	Range
Symbol rate	10.7622378 MHz ± 30 Hz
Transport rate	19.3926585 MHz ± 54 Hz

5.1.16. Decoder interface

The decoder interface shall be compliant with the IEEE 1394 standard, amendments, and performance guidelines for serial digital interfaces.

5.1.17. Closed captioning

The receiver shall provide closed captioning in accordance with the EIA-708-B standard, amendments, and performance guidelines.

5.1.18. Receiver functionality

The receiver shall utilize the Program and System Information Protocol (PSIP) in accordance to ATSC standard A/65A and ATSC implementation guideline A/69. The following minimum set of functional requirements shall be implemented.

5.1.18.1. Direct access to any channel

The receiver shall support the ability to access any analog or digital channel by direct entry of its channel number.

5.1.18.2. Service grouping

The receiver shall support grouping of selected digital services with an existing analog service.

5.1.18.3. Channel branding

The receiver shall permit the use of broadcaster legacy channel labels for digital channels.

5.1.18.4. Channel naming

The receiver shall support the downloading of the textual name or call sign associated with each program source.

5.1.18.5. System Time Table (STT)

The receiver shall support a timetable in accordance with the ATSC A/65A standard, amendments and associated recommended practices.

5.1.18.6. Terrestrial Virtual Channel Table (TVCT)

The receiver shall provide a channel table in accordance with the ATSC A/65A standard, amendments and associated recommended practices.

5.1.18.7. Rating Region Table (RRT)

The receiver shall support a regional rating table in accordance with the ATSC A/65A standard, amendments and associated recommended practices.

5.1.18.8. Event Information Table (EIT)

The receiver shall provide an event information channel in accordance with the ATSC A/65A standard, amendments and associated recommended practices.

5.1.19. Video Interfaces

The receiver shall decode all video formats in accordance with the ATSC A/53B standard, amendments and associated performance guidelines.

5.1.19.1. Analog Video Interfaces

The receiver shall provide three analog component outputs corresponding to Y, P_r, and P_b, capable of driving 75 ohm cables using RCA-type connectors in accordance to SMPTE 274-1998 for 1080 Scanning Systems or SMPTE 296M-1997 for 720 Scanning Systems while also including all amendments and associated recommended practices. The receiver should also provide a RGB video monitor output.

5.1.19.2. Digital Video Interface

The receiver shall provide a Digital Video Interface (DVI) in accordance with the SMPTE 274-1998 standard for 1080 scanning systems.

5.1.20. Audio Interfaces

5.1.20.1. Analog Audio Interface

The receiver shall provide stereo analog audio interfaces corresponding to left and right on RCA-type connectors capable of driving 75 ohm cables at a nominal 1.0 volt peak-to-peak signal.

5.1.20.2. Digital Audio Interface

The receiver shall provide a digital audio interface using a Toslink-type fiber optic connector in accordance to JEITA standard CP-1201. The data format shall be AC-3 in the IEC 61937 format as specified in ATSC A/52A Annex B.

5.2. Antenna Characteristics

When an antenna is provided for indoor use, the antenna shall be directional with an antenna control interface, preamplifier, polarization control, and directivity control and shall have the following characteristics.

5.2.1. RF Connector

The antenna shall provide a 75 ohm \pm 10 ohm RF cable and male F-type connector to the receiver.

5.2.2. Antenna Control interface

The antenna shall have an antenna control interface in accordance with the EIA/CEA-909 standard and shall utilize the interface to control preamplifier gain, polarization, and directivity.

5.2.3. Preamplifier

The antenna shall contain a preamplifier capable of having its gain controlled through the antenna control interface. The preamplifier shall have the characteristics described in Table 9.

Table 9 – Antenna preamplifier characteristics

Parameter	Value
Frequency range	VHF and UHF
Noise figure	3 dB
Minimum gain	0 dB
Maximum gain	20 dB
Number of gain steps	4

5.2.4. Polarization Control

The antenna shall be capable of operating with either horizontal or vertical polarizations. The receiver shall select the polarization through the antenna control interface.

5.2.5. Antenna Gain

The antenna shall have a forward gain of at least 4 dB. The front-to-back ratio of the antenna shall be at least 15 dB.

5.2.6. Directivity and Control

The antenna shall be directional with a half power beam width not-to-exceed 75 degrees. The antenna shall be capable of steering in steps of 22.5 degrees.