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PolyCom HDX 9004 (9000 - 720)

Manufacturer: Polycom

Model: HDX 9004

Software Version: 2.6.1.3

Optional Features and Modifications: 8 site MCU

Date of Test: 1st – 5th November 2010

A: INTRODUCTION

We requested 9000 series CODECS for evaluation from Polycom UK who in turn supplied two 9004 systems. Towards the end of the evaluation period it became evident that discrepancies existed between the performance of these 9004 CODECs and the published 9000 series data sheet. Polycom informed us that the 9000 series had been rationalised into two models: the 9000-720 and the 9000-1080, Polycom assured us that the 9004 equipment evaluated in this report is the same hardware and software as the 9000-720 with the exception of a higher maximum call speed of 6Mbit/s available with the 9000-720.

The Polycom® HDX 9004 CODEC has a maximum picture resolution of 1280 x 720 pixels (i.e. 720p). Designed for HD conferences between Polycom® HDX systems and other manufacturers HD CODECS, it remains compatible with standard definition (SD) H.323 CODECS at the basic CIF resolution. Options also include:

- H.320 ISDN connectivity
- Onboard high definition MCU for up to four or eight connections.

This room-based system offers comprehensive input and output interfaces and a wide range of video formats.

HDX 9004 Feature Summary:

- A high definition videoconferencing systems which supports variable resolution up to a maximum of 1280 x 720 pixels (720p)
- A 2U high rack mounted IP CODEC operating at connection speeds up to 4 Mbit/s over H.323
- Optional ISDN (H.320) connectivity up to 2Mbit/s, with either PRI or BRI interfaces
- High definition pan and tilt camera and a second HD camera input
- HD video input (analogue component)
- Standard definition Composite and Y/C input
- Up to four monitor outputs

- Supports H.261, H.263, H.263+ and H.264 video coding.
- Supports G.711, G.722, G.722.1, G.729, G.729A, Siren 14 and Siren 22, audio coding including Polycom® StereoSurround™.
- Multiple microphone pod option
- DVI-I PC data input
- Stereo analogue audio inputs for connection of DVD/VCR, PC audio and an external microphone mixer
- Stereo-surround audio
- Far-end camera control and video source selection.
- H.239 dual video
- An optional four or eight site internal H.323 MCU with either continuous presence or voice switched operation.
- Audio bridge facility.

B: SETUP PROCEDURE

The Polycom® HDX 9004 system includes a CODEC together with an HD camera unit, ideally placed above or below the main picture monitor. An external microphone and infra red remote control completed the package. Cabling the system was straightforward and involved:

- Connecting the supplied DVI video and audio leads between the CODEC and a high definition display monitor or monitors.

- Cabling the CODEC to the camera through the multi-core HDCI cable.
- Plugging the microphone unit to the CODEC.
- Establishing network connection through one RJ-45 to RJ-45 lead.
- Connecting power to the unit.

System set up was conveniently configured through the “on-screen” menus via the hand held infrared remote control. IP address, Gateway, Subnet mask and Gatekeeper addresses were all entered using this method. Once IP connectivity was established the web interface provided a more convenient method of adjusting the system settings.

Approximate set-up time: 20 minutes

Documentation quality: The documentation was concise and easy to follow and included: Setup, Quick Tips, User’s and Administrator guides.

The set up procedure was convenient and trouble free.

C: Hardware Description

HDX 9004 System

The HDX 9004 systems supplied for evaluation had a maximum call bandwidth of 4 Mbit/s. One system included an onboard high definition 8 site MCU.

The CODEC offers several video resolutions including:

- CIF 352 x 288 pixels
- 4CIF 704 x 576 pixels
- High definition w720p i.e. 1280 x 720 @ 30 frames per second

The received image resolution is dependent on the call connection bandwidth and the optimisation selected for the input source i.e. either motion or sharpness, as shown in the table:

Connection bandwidth	Camera optimised for motion	Camera optimised for sharpness
128 Kbit/s	CIF 352 x 288	4 CIF 704 x 576
384 Kbit/s	2 CIF 704 x 288	4 CIF 704 x 576
768 Kbit/s	2 CIF 704 x 288	4 CIF 704 x 576
1 Mbit/s	4 CIF 704 x 576	720p 1280 x 720
1.5 Mbit/s	4 CIF 704 x 576	720p 1280 x 720
>1.5 Mbit/s	720p 1280 x 720	720p 1280 x 720

The 9004 CODEC supports single monitor mode with both Picture in Picture (PIP) and Picture outside Picture (POP) being available. Four user definable video outputs are also

offered to interface with a variety of monitoring solutions. For connection to high definition displays i.e. data monitors or projectors, both the single output 1and dual output 2 main monitor outputs may be configured as either HDMI, DVI, VGA or component video. Standard composite and Y/C outputs are also offered. Video output 3 may be analogue composite or Y/C only while video output 4 can be selected to VGA, DVI or component formats. The CODEC video outputs are thus adaptable to most installations. Video output 3 is compatible with video recorders for recording conferences.

Comprehensive picture monitor settings allow the video format and aspect ratio to be altered and can determine how the People and Content images of both transmitted and received signals are displayed locally. The options available are:

• **None**—Preserves the aspect ratio of the source video: The image is scaled (if necessary) to the largest supported resolution that fits on the display without cropping. Unused areas of the display are filled with black borders.

• **Stretch**—Aspect ratio not preserved: The image is scaled horizontally and vertically to match exactly the resolution of the display.

• **Zoom**—Preserves the aspect ratio of the source video: The image is scaled to exactly match one of the display dimensions while matching or exceeding the other display dimension. The image is centred and cropped.

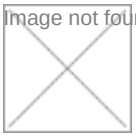
During the evaluation we did not select stretch or zoom but maintained the native aspect ratios.

In single monitor mode when viewed on a large widescreen monitor or data projector the Picture outside Picture feature display's multiple images showing near and far pictures together with transmitted or received Content. Various layouts may be selected through the display button on the remote control:

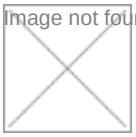
1. Near and far sites, same size, side by side
2. Far site big, near site small
3. Near site big, far site small
4. Near site, full screen
5. Far site, full screen

Unless the setting is changed, the previously selected screen layout is stored as the default for subsequent calls.

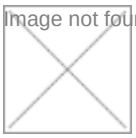
When content is displayed, two small images of the near and far presenters appear alongside the larger content image, layouts may be altered through the display button.



Point to Point Call, Picture outside Picture (POP) no content



Point to Point Call, Picture outside Picture (POP) no content, far end large.

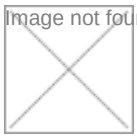


Point to Point Call, Picture outside Picture (POP) with 4x3 content

The Polycom® EagleEye high definition camera has a native resolution of 1280 x 720p and features pan, tilt and zoom functions with a wide horizontal viewing angle of 72 degrees. The camera connects to the CODEC through a single proprietary HDCI cable. The cable supplied for evaluation was approximately 3 metres in length but this may be extended to 30 metres without signal boosters. Above 10 metres a separate power supply is however required to locally power the camera. Ten camera preset positions may be stored and recalled via the remote control at any time during a call.

Five video inputs provide a comprehensive range of interfaces. Another Polycom® Eagle Eye camera may be connected to the second HD camera input, or by using the supplied breakout cable, other video sources including: HD component video, Y/C (S-video) or composite video may also be used as a picture source. Video input 3 is switchable between S-video (Y/C), composite video and component video. Inputs four and five are switchable between VGA and DVI.

A feature of the HDX system is People ‘on’ Content (conventionally called “Chroma Key” or “Colour Separation Overlay”) to create an artificial background behind a presenter. For example a weather presenter could be superimposed over a map of the UK (derived from a PC image). This requires the presenter to be positioned in front of a plain green background and viewed by the main HD camera. The green areas of the image (i.e. not the presenter bits) then cause an electronic switch to select the appropriate parts of the map for superimposition. Unfortunately the quality of these “chroma-key” images is very variable and is critically dependant on the quality of the lighting on the presenter. It can be very difficult to reduce the ‘shimmering’ effect around the edge of the presenter image.



People on Content

In the image above, the X-ray monitor image was provided from a video player to produce the “Content” signal and the green screen wall behind the presenter was lit very carefully. Under these conditions very acceptable results were achieved.

The high definition MultiSite (MCU) option provides either four or eight sites (Host HDX CODEC plus three or seven remote sites). The speed of each connection is dependent on the total number of sites in the MCU conference and the bandwidth capability of the CODEC. Audio bridging is also possible through the onboard MCU when a standard telephone line is

connected to the CODEC.

Speed of connection for the HDX9004 MCU with a maximum overall bandwidth of 4Mbit/s:

Number of Sites	Maximum Speed for each Site in Kbit/s
3	1920
4	1344
5	1024
6	768
7	640
8	512

During an H.323 call a second unidirectional video channel is provided through H.239, but without a second audio channel. For these People and Content conferences the bandwidth may be automatically allocated between each channel or split in the ratios, 50/50, 90/10 or 10/90 up to the limits of the maximum available connection speed. Thus video from a camera and a second source e.g. a PC image could be transmitted simultaneously and displayed on two monitors at the remote site. Dual video H.239 operates in point-to-point calls between HDX systems and interoperates with other Polycom® standard definition products. In multi-site calls via the internal HDX MCU, H.239 interoperated with HD and SD systems from a range of vendors.

Several audio formats are supported by the CODEC. Polycom has implemented the Siren 22 audio protocol with 22KHz analogue audio bandwidth, including StereoSurround™. The system captures stereo by using two of the three microphones within the desk microphone pod to create the stereo image. For faithful stereo the microphone pod must be placed as illustrated below with the Polycom logo closest to the conference participants. Alternatively the Stereo Autorotation feature may be used to configure the microphone. This feature senses sound energy from the left and right speakers and automatically assigns left and right channels to the microphone elements.

In larger rooms the microphone pods may be daisy-chained to provide improved coverage. Stereo is still supported with multiple microphone pods. Each pod has a mute button with LEDs that indicate the status; changing from green to red when muted.

Microphone Pod with green LEDs lit (‘live’)

Separate stereo inputs using phoenix connectors allow straightforward interfacing to standard VCR/DVD players and PC’s. When audio accompanies the video material this will only be transmitted to the remote site and heard via the local loudspeaker when the appropriate vision signal has been selected. This practical feature is not always present in other vendor’s products. As appropriate, echo cancellation is disabled for these two inputs but a dedicated auxiliary line level input allows an external microphone mixer to be connected where echo cancellation may be enabled or disabled. This auxiliary audio signal is only transmitted to the remote sites and not heard locally, the table below summarises these features:

Audio Input	**Echo cancellation**	**Transmitted to remote site**	**Heard locally**
Auxiliary	Switchable On/Off	At all times	No
VCR/DVD	No	Only when the VCR/DVD Video source is transmitted	Yes
Content	No	Only when the VGA PC input is transmitted	Yes

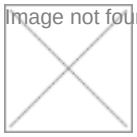
A special case arises when the breakout cable is used to connect HD component, Y/C or composite video to either video 1 or 2 inputs. When either of these video inputs is selected only the auxiliary audio input will be live, and its audio will be transmitted to the remote site but will not be heard locally.

The CODEC may be operated locally through the remote control or can be interfaced to a room control system through the serial port on the rear panel. It may also be configured remotely via a web browser from a network connected PC. For added security this remote management system may be password protected. The comprehensive web interface provides control and configuration of the CODEC and displays diagnostic information if required together with web snapshots of near and far images from the CODEC.

D: SYSTEM OPERATION

The remote control has a central “OK” button surrounded by two concentric rings. The outer ring controls near/far camera selection, zoom and volume controls, the inner ring selects the pan and tilt of the near or far cameras and the on screen menu navigation.

At the top of the remote a small LCD screen provides confirmation of button selection. Buttons are dedicated for: Call, Hang-up, Directory, Camera selection, Camera presets, Media (Content) selection, display layout and System Information/Help.



HDX Remote Control

The ‘Info’ button has dual functions, providing context sensitive help when not calling and a shortcut to Call Status information during a call. When using the single monitor option the display button is used to cycle between screen display options.

When the remote control is picked up the on-screen display indicates: near/far camera control, encryption status, far site name and call duration. This display disappears after several seconds if the remote is then put down.

During People + Content™ or H.239 calls each input source to the HDX CODEC must be designated either “People” or “Content”. People images are transmitted on the main video channel at a high frame rate while Content images are transmitted on the second video channel at a lower frame rate. Content may be transmitted at a high frame rate if the content source is optimised for Motion, however this will result in a low resolution image being transmitted. The Camera button on the remote control selects People images and the Media button, Content.

An H.239 (dual video) conference is initiated and terminated by pressing the Media button and then selecting the second image input. The main camera normally occupies the first channel and the other selected image source the second channel. The two signals are then sent to the remote site for display on two picture monitors. The second or “Content” image is restricted to around 6 frames per second depending on the negotiated resolution which is satisfactory for PC still images but not for moving sequences e.g. VCR/DVD material or PC data with embedded video or animation. Section E explains this in more detail

Successful H.239 conferences were established in both directions between HDX systems and in conferences with other vendors CODECS.

The HDX CODECs support both remote camera control and remote video source selection.

When viewing a group of conference participants i.e. with the camera in wide angle or zoomed out, the stereo audio (StereoSurround™) performed well. The stereo effect definitely helped to identify the position of the particular participant speaking in the group. When the camera was zoomed in (close-up) however the stereo image did not alter to suit the close up view of the presenter, and the accompanying sound did not match. In other words, the video image showed the speaker ‘centre stage’ while the stereo audio ‘image’ remained with the speaker off to the right or left, which could be

distracting for some users.

The system takes two minutes to boot up from cold, when not in a call the system automatically reverts to sleep mode after a user definable period. An incoming call

or movement of the remote control (picking it up), will return the system to active

mode.

MCU Operation

Controlling an MCU conference is a simple procedure:

1. Select the “Call” button during a call
2. Enter the number of the additional site into the call menu or select the site from the directory or the recent call list.
3. Press the “OK” or Call button?
4. The additional site will then be connected to the conference.

Individual connections or all connections may be disconnected using the graphic interface.

The MCU may be set to operate in a number of screen display configurations:

Full Screen The site that is speaking is shown full screen to all other sites. This mode is also known as voice-switching; when the next speaker starts talking their image is automatically switched to all other sites while the current speaker sees the previous speaker.

Presentation The speaker sees up to 4 other sites in a split screen while all the other sites see the speaker in full screen mode. A useful mode when one site is making a significant presentation.

Discussion All sites are displayed simultaneously in separate quadrant windows on the display. If there are more than 4 sites in the conference then voice switching is used within the quadrants to ensure that sites which are taking part in the discussion are displayed.

Auto The system switches between Presentation and Discussion modes, depending on the interaction between the sites. If multiple sites are talking at the same time, Discussion mode is used. If one site is talking and uninterrupted for at least 15 seconds, Presentation mode is used and the speaker appears full screen.

Content may also be shared in an MCU conference

MCU Conference in Discussion Mode (Dual Monitor)

In Dual Monitor mode the ’Main’ screen displays a matrix of the remote sites in the conference in a split screen (see above left) and the second screen displays the current speaker if a

remote site is speaking or the previous speaker if the local site is speaking. The current speaker is indicated by the border around the image quadrant changing from blue to yellow, just perceptible above.

Image not found or type unknown

MCU Conference in Discussion Mode with Content (Dual Monitor)

With content is transmitted or received the right hand screen above displays the sites in the conference in a split screen and the left hand screen displays the content full screen. The Content channel could deliver either high resolution or high frame rate images but could not deliver both together. This could present problems for some material.

The comprehensive statistics menu displays call status data including resolution, connection speed, compression protocols and packet loss. The comprehensive suite of diagnostic menus includes audio bar graphs for all audio input and output connections of the system. These features are particularly helpful in configuring the system and during problem solving or fault diagnosis.

Remote configuration, monitoring and control are available via a web browser, with optional password protection security. This is a very useful tool for configuring the system and checking call status, it also includes the ability to initiate and terminate calls.

Web Interface Screen Shots:

Image not found or type unknown

Call Status

Image not found or type unknown

System Configuration

Screen shots of the transmitted and received images are also available from the web interface using either “Remote Monitoring” which provides snapshots of the near and far video images or “Web Director” which provides additional CODEC control as well as participant screenshots.

Image not found or type unknown

Remote Monitoring

Image not found or type unknown

Web Director

Screenshots reproduced by permission of Polycom®

E: VIDEO TESTS SUMMARY

High Definition Image Quality

During point to point conferences between HDX units the resolution and overall image quality for calls at 2Mbit/s and above was good. When viewing the image on a 720p HD display the fine detail and texture was considered to be very good. Subjectively, the ratings in the detailed video tests in Appendix 2 showed a marked improvement when compared to earlier versions of the 9000 series hardware and software tested in 2007.

In calls between HDX systems, resolution and thus image quality on the main “People” video channel, is dictated by the connection bandwidth and the setting of the Motion/Sharpness optimisation control for each video input. Tests were carried out at various bandwidths and settings of the Motion/Sharpness for both the Eagle Eye Camera and a Sony Playstation 3. The latter had its output resolution set at 720p and was connected via the analogue component input 3 to the CODEC.

Video transmitted on Channel 1 “People”

Connection Bandwidth	Motion Camera	Motion Playstation	Sharpness Camera	Sharpness Playstation
384 Kbit/s	2CIF 352 x 288	2CIF 352 x 288	4 CIF 704 x 576	4 CIF 704 x 576
768 Kbit/s	2 CIF 704 x 288	2 CIF 704 x 288	4 CIF 704 x 576	4 CIF 704 x 576
1 Mbit/s	4 CIF 704 x 576	4 CIF 704 x 576	720p 1280 x 720	720p 1280 x 720

2 Mbit/s	720p 1280 x 720	720p 1280 x 720		720p 1280 x 720	720p 1280 x 720
4 Mbit/s	720p 1280 x 720	720p 1280 x 720		720p 1280 x 720	720p 1280 x 720

When high frame rate HD video material was replayed from the Playstation 3 via input 3 the overall video quality at 2Mbit/s was good improving to very good at 4Mbit/s. The main effect is seen at the lower bandwidths where increasing Sharpness reduces the repetition frequency or frame rate and thus degrades movement. At speeds below 2Mbit/s with complex high movement images the frame rate was observed as dropping to around 15 frames per second.

Similar tests were carried out with the Playstation 3 720p image transmitted on the second H.239 “Content” channel. The balance of bandwidth between People and Content was selected as auto. In a 4Mbit/s call with the Content channel optimised for sharpness the highest resolution and frame rate experienced was 720p at 6fps, with the content channel optimised for motion the highest resolution and frame rate experienced was 2SIF at 25fps. To ensure good results when transmitting motion sequences the source video must use channel 1 (People), and ‘motion’ mode selected. This guarantees that the optimum frame rate will be negotiated. When the bandwidth exceeds 1.5 Mbit/s then HD resolution video will also be transmitted.

System data sheets and general documentation published on the web do not indicate the systems inability to transmit content at both a high resolution and frame rate, this will present problems for some material if transmitted as Content. The 9000 series data sheet states “Content Frame Rate: 30fps”

F: AUDIO TESTS SUMMARY

Setup The echo canceller is fully automatic in operation. The quality of echo cancellation and doubletalk from the system was excellent.

	Lecture Theatre	Room
Audio levels adequate? (Yes/No)	Not tested	Yes
Audio quality acceptable? (Yes/No)	Not tested	Yes
Echo cancellation acceptable? (Yes/No)	Not tested	Yes

Quality of double talk	Not tested	Excellent

G: DATA TESTS

A PC may be directly connected to the CODEC via the DVI-I interface.

H: CONNECTIVITY

Connectivity between Like Machines

H.323

There were no problems in establishing connections between the HDX units over IP.

During an H.323 call the network connection was removed and reconnected after a specific time:

The normal 5 seconds test could not be checked as the calls dropped immediately, this is very unusual after such a short period as calls with other vendors products typically reconnect after up to a 30 seconds network disconnection/reconnection.

Time to Connect

H.323

All speeds	Approx. 3 seconds

Connectivity with Other Machines (models listed with comments)

Connections were made in each direction with the following CODEC's at their maximum connection speed. H.239 connections were also initiated.

H.323

CODEC	**Resolution Transmitted by the Polycom® HDX 9004**	**Resolution Received by the Polycom® HDX 9004**
Tandberg 6000 Classic (B Version Hardware)	SIF	CIF
Polycom® VSX7000e	CIF	CIF

ConnectC		
Polycom® PVX	CIF	QVGA
Tandberg 990 MXP*	2CIF	w448p
Tandberg Edge 95*	2CIF	w720p
Tandberg 6000 MXP*	2CIF	w720p
Lifesize Room 200*	w720p	w720p
Lifesize Team**	w720p	w720p

* In calls between the HDX 9004 and Tandberg HD CODECS the Polycom only transmitted ***2CIF (704 x 288)***.

** In calls between the HDX 9004 and Lifesize CODECS although Siren 14, 48K was negotiated in both directions ***no audio*** was received at the Polycom sites.

Connectivity with JANET Videoconferencing Switching Service (JVCSS)

H.323 Standard Definition

The HDX connected to the MGC MCU using H.263 Video and G.722 audio in both directions, negotiated resolution was CIF. H.239 interoperated successfully.

Received audio level was measured as peaking to -4dBm.

H.323 High Definition

The HDX connected to the Codian MCU using H.264 Video and G.722 audio in both directions, negotiated resolution was 720p. H.239 interoperated successfully.

Received audio level was measured as peaking to -4dBm.

Procedure for making a call

1. Press Call button on the remote control
2. Select connection speed
3. Input IP address or E.164 number
4. Press the OK button or press the call button.

Local Contacts Directory and Recent Call list are also available from the user interface.

Appendix 1 Detailed Physical Information

Dimensions: (w x h x d) 43 x 8.7 x 37 cm

Video Inputs	Format	Connector
Video 1, camera 1	HD	HDCI
Video 2, camera 2	HD, Composite, Y/C,Component	HDCI
Video 3	Composite, Y/C,Component	3 x BNC

Video 4	VGA, DVI	DVI-I
Video 5	VGA, DVI	DVI-I

Video Outputs	Format	Connector
Video 1	VGA, DVI, Component	DVI-I
Video 1	Composite or Y/C	2 x BNC
Video 2	VGA, DVI, Component	DVI-I
Video 2	Composite orY/C	2 x BNC
Video 3	Composite Y/C	Y/C
Video 4	VGA, DVI, Component	DVI-I

Audio Inputs	Level	Connector
HDX microphone	**Line**	RJ45
HDX microphone	**Line**	RJ45
Audio input 1, main audio (stereo) or to connect an external mixer	Line	Phoenix x 2

Audio input 2 VCR/DVD (stereo) linked to video in. 3	Line	Phoenix x 2
Audio input 3 PC (stereo) linked to video input 4	Line	Phoenix x 2

Audio Outputs	Level	Connector
Audio output 1 Main audio (stereo)	Line	Phoenix x 2
Audio output 2 VCR (stereo)	Line	Phoenix x 2

Data

1. 1 off LAN 10/100 Mbits/s Ethernet connection (RJ45)
2. 1 off H.320 interface bay
3. 2 off RS232 data connection (9 pin D type)
4. 1 off USB connector (future use)
5. 1 off Firewire connector (future use)
6. 1 off PCMCIA expansion slot (future use)
7. 1 off IR receiver connector (Phoenix)
8. 1 off RJ11 analogue telephone line input

Cables Supplied

As the units supplied for evaluation were demonstration units we cannot comment on cables supplied with new production systems.

Mobility

The HDX 9004 system is a 2U Rack mounted CODEC intended for permanent installation but which could be moved. To establish a connection each new location will need the local LAN and IP data to be re-entered into the configuration menu.

Appendix 2 Detailed Video Tests

Note: The HDX system supports, H.261, H.263, H.263+ and H.264, however it is not possible to force the H.261 or H.263 protocols in calls between HDX units. Subsequently, in the video tests below, only the H.264 (default protocol) was negotiated by the CODEC

For the following tests using the composite video input, video resolution between HDX systems was 4xCIF.

For the following tests at 384 Kbit/s the corresponding audio protocol was **Siren 22, 48Kbit/s** and for all connection speeds above 384 Kbit/s was **Siren 22, 64 Kbit/s.**

Objective Video Tests: Signal measurements

1. 75% EBU bars
2. Grey scale

Subjective Video Impairments Tested:

Lip synchronisation	**LS**
Block distortion (tiling)	**BLK**
Blurring (reduced edge sharpness and spatial detail)	**BLR**
Colour errors	**CLR**
Jerkiness (distortion of smooth motion)	**JRK**
Object persistence (lagging images from previous frames as faded or outline images)	**OP**
Scene cut response (i.e. time to build up the new image)	**SCR**

Scale of impairments:

Imperceptible	**1**
Perceptible	**2**
Slightly annoying	**3**
Annoying	**4**
Very annoying	**5**

MII Test Tape:

Signals recorded	Time on tape
1. EBU colour bars	1min 30secs
2. Grey scale	1.40 - 2.40
3. Blue field	2.50 - 3.50
4. Medium close up female face, still	4.00 - 5.00
5. Medium close up female face, talking	5.10 - 6.10
6. Close up face, nodding	6.20 - 7.20
7. Close up face, shaking head side to side	7.30 - 8.30
8. Zoom out slowly to wide angle three people	8.40 - 9.40
9. Zoom in quickly to close up of centre person	9.50 - 10.50
10. Turntable speeds: 1,2,3 and 4	11.00 - 15.30
11. Football sequence	15.40 - 16.40
12. Zoom in and out of "A to Z" map	16.50 - 17.50
13. Text legibility, font sizes 20 to 12 pt	20.30 - 20.50
14. Cut tests, scenes various with camera movements	21.00 - 22.00
15. Man teaching at whiteboard	22.10 - 23.23

(Insert 75% EBU bars at local site, measure at remote site)

Test 1 (H264): Colour bar test

(Insert 75% EBU bars at local site, measure at remote site)

Peak to peak video amplitude	1.0 v
Peak to peak sync amplitude	0.3 v
Peak to peak burst amplitude	0.3 v
Do chroma vectors lie in their boxes?	Yes
Any waveform aberrations?	None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	1	1	1	1

BLR	1	1	1	1
CLR	1	1	1	1

Test 2 (H.264): Grey scale

(Insert grey scale at local site, measure at remote site)

Peak to peak video amplitude	1.0 v
Peak to peak sync amplitude	0.3 v
Any waveform aberrations?	None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	1	1	1	1
BLR	1	1	1	1
CLR	1	1	1	1

Test 3 (H.264): Blue screen

(Insert blue screen at local site, measure at remote site)

Any waveform aberrations?	None

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	1	1	1	1
CLR	1	1	1	1

Test 4 (H.264): Medium close up female (still)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	1	1	1	1
BLR	2	1	1	1
CLR	1	1	1	1

Test 5 (H.264): Medium close up female (talking)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
LS	1	1	1	1
BLK	2	1	1	1
BLR	2	2	1	1
CLR	1	1	1	1
JRK	1	1	1	1

Test 6 (H.264): Close up head (nodding)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	2	1	1
BLR	2	2	2	1

CLR	1	1	1	1
JRK	1	1	1	1

Test 7 (H.264): Close up head (shaking side to side)

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	2	1	1
BLR	3	2	2	1
CLR	1	1	1	1
JRK	1	1	1	1

Test 8 (H.264): Medium close up, slow zoom out to three shot

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	2	1	1
BLR	2	1	1	1
CLR	1	1	1	1
JRK	1	1	1	1

Test 9 (H.264): Three shot, quick zoom in to medium close up centre person

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s

BLK	2	2	1	1
BLR	2	1	1	1
CLR	1	1	1	1
JRK	1	1	1	1

Test 10a (H.264): Turntable speed 1

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	1	1	1
BLR	2	1	1	1
CLR	2	2	1	1
JRK	1	1	1	1

Test 10b (H.264): Turntable speed 2

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	1	1	1
BLR	2	2	1	1
CLR	2	2	1	1

JRK	2	1	1	1

Test 10c (H.264): Turntable speed 3

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	2	2	1
BLR	3	3	2	2
CLR	2	2	2	2
JRK	2	1	1	1

Test 10d (H.264): Turntable speed 4

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	3	2	2	1
BLR	3	3	2	2
CLR	2	2	2	2
JRK	2	1	1	1

Test 11 (H.264): Football sequence

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s

BLK	4	2	2	1
BLR	4	3	2	2
CLR	2	2	2	2
JRK	1	1	1	1

Test 12 (H.264): Zoom in and zoom out of ‘A to Z’ map

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	4	2	2	1
BLR	4	2	2	2
CLR	1	1	1	1
JRK	3	3	2	2

Test 13 (H.264): Text legibility (% of screen height) at viewing distance approx. 5x screen diagonal

Legibility H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
20 pt (3.5%)	**Yes**	**Yes**	**Yes**	Yes
16 pt (3%)	**Yes**	**Yes**	**Yes**	Yes
14 pt (2.5%)	**Yes**	**Yes**	**Yes**	Yes

12 pt (2.3%)	**No**	**Yes**	**Yes**	Yes

Test 14 (H.264): Video with several vision cuts

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
BLK	2	2	2	1
BLR	3	2	2	2
CLR	1	1	1	1
OP	1	1	1	1
SCR	3	2	2	2
JRK	2	2	1	1

Test 15 (H.264): Man teaching with flip chart

Subjective Impairments H.323	384 kbit/s	768 kbit/s	2.0 Mbit/s	4.0 Mbit/s
LS	2	2	1	1
BLK	2	1	1	1
BLR	2	2	1	1
CLR	1	1	1	1

JRK	1	1	1	1

Test 16 Playback from a domestic VHS videotape player

Is picture stable?	Yes

Appendix 3 Detailed Audio Tests

Note: In tests between HDX 9004 units it was not possible to force audio protocols so only a limited range of audio protocols could be fully tested.

Test 1: Frequency response (-3 dB)

(Insert -6 dB signal at local site, measure at remote site)

G.722.1 Annex C	Siren 22 48Kbit/s	Siren 22 64Kbit/s
14 KHz	22 KHz	22 KHz

Test 2: Headroom (measured on Siren 22 64Kbit/s connection)

(Insert increasing amplitude 1 KHz tone at local site, monitor for overload distortion at the remote site auxiliary output.)

Overload occurs at: +15 dBm

Test 3: Audio level

(Insert 0dBm 1KHz tone at local site, monitor the received level at the remote site VCR output)

Remote site signal measures: -6 dBm

Test 4: Echo Cancellation

Setup The echo canceller is fully automatic in operation. The quality of echo cancellation and doubletalk from the system was excellent.

	Lecture Theatre	Room

Audio levels adequate? (Yes/No)	Not tested	Yes
Audio quality acceptable? (Yes/No)	Not tested	Yes
Echo cancellation acceptable? (Yes/No)	Not tested	Yes
Quality of double talk	Not tested	Excellent

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