APPENDIX 11/04

TEST RESULTS FOR POLYCOM® HDX 4500

Manufacturer:	**Polycom®**
Model:	**HDX 4500**
Software Version:	**3.0.3-14451**
Optional Features and Modifications:	**1080p Resolution**
Date of Test:	**14th – 18th November 2011**

System front view

HD Camera

Control Panel

C O N T E N T S

A: INTRODUCTION

The Polycom® HDX 4500 is a self contained desktop High Definition (HD) videoconferencing system with a maximum picture resolution of 1920 x 1080 pixels (1080p) at 30fps. It is the highest specification model in Polycoms HDX 4000 series of conferencing solutions. The system comprises a 24" picture monitor, CODEC, camera, microphones and loudspeakers integrated into a single desktop unit. Compatibility with other H.323 and SIP CODECs is achieved across a range of resolutions from SIF (352x240 pixels) up to 1920 x 1080 depending on the capability of the remote CODEC and the connection bandwidth.

Available options include:
1080p resolution
4 Site Multipoint Conference unit (MCU)

The systems supplied for evaluation included the 1080p option only.

HDX 4500 Feature Summary:
- A high definition videoconferencing system which supports variable resolutions up to a maximum of 1920 x 1080 pixels (1080p) at 30fps or 1280 x 720 pixels (720p) at 60fps.
- A single integrated unit comprising: The 24" picture monitor, CODEC, camera, dual microphones and loudspeakers.
- An IP CODEC operating at connection speeds up to 4 Mbit/s over H.323
- A fixed HD camera with 1920 x 1080 native resolution and a manual privacy shutter feature.
- Dual monitor support.
- Supports H.261, H.263, H.263+, H.264 and H.264 High Profile video coding.
- Supports G.711, G.722, G.722.1, G.728, G.729A, Siren 14 and Siren 22, audio coding including Polycom® StereoSurround™.
- External microphone input
- Stereo headphone output
- DVI PC data input
- Stereo analogue audio input for connection of PC audio
- Stereo-surround audio
- Far-end camera control
- H.239 second HD video connection with up to w1080p (1920 x 1080) resolution
- Optional four site internal H.323 MCU with either continuous presence or voice switched operation
- AES Encryption

B: SETUP PROCEDURE

Installing the Polycom® HDX 4500 system was straight forward. The Quick Start Guide clearly illustrated this simple procedure:

- Connect the control panel to the unit.

- Connect the RJ45-RJ45 cable to establish an Ethernet IP network connection

- Connect mains power to the unit.

System set up was also convenient and trouble free. The IP address, IP Gateway, Subnet mask and Gatekeeper address were all configured by the control panel through the on screen menus.

Approximate set-up time: 15 minutes

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

C: HARDWARE DESCRIPTION

HDX 4500 System

The HDX 4500 systems supplied for evaluation had a maximum call bandwidth of 4 Mbit/s and included the 1080p (30fps) option.

The CODEC offers several video resolutions including:

- SIF   352 x 240 pixels
- CIF   352 x 288 pixels
- 2CIF   704 x 288 pixels
- 4CIF   704 x 576 pixels
- High definition w720p   i.e. 1280 x 720 @ 60 frames per second
- High definition w1080p i.e. 1920 x 1080 @ 30 frames per second

The image resolution and frame rate are dependent on the call connection bandwidth and the video mode (Motion or Sharpness), the default setting being Sharpness:

Video Mode	Sharpness		Motion	
Connection Bandwidth	Resolution	Frame rate	Resolution	Frame rate
128 Kbit/s	704 x 576	25fps	352x288	50fps
384 Kbit/s	704 x 576	25fps	704x288	50fps
768 Kbit/s	1280 x720	25fps	704 x 576	50fps
1 Mbit/s	1920 x 1080	25fps	1280x720	50fps
2 Mbit/s	1920 x 1080	25fps	1280x720	50fps
4 Mbit/s	1920 x 1080	25fps	1280x720	50fps

To maintain picture sharpness (resolution) at the lower connection bandwidths the frame rate was reduced as movement increased within the image

The HDX 4500 CODEC supports both single and dual monitor modes. When multiple images are displayed on a single monitor only Picture outside Picture (POP) is displayed, Picture in Picture (PIP) is not available. The second monitor output may be configured as DVI, VGA or component video to cater for high definition signals.

The Perspex screen across the front of the monitor was highly reflective and degraded the image quality.

The aspect ratio and the video format of displayed images can be selected from the comprehensive range of settings. This allows both transmitted and received images to be optimised locally for both People and Content signals.

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.

Only the "None" setting was used during the evaluation.

In single monitor mode using the HDX4500 monitor only two images may be displayed as a POP. Various layouts may be selected through the Layout button on the remote control panel:

No Content being transmitted or received.

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

Point to Point Call, Picture outside Picture (POP) no content, near and far sites side by side

**This image clearly shows the screen reflections**

Point to Point Call, Picture outside Picture (POP) no content, far site large, small near site.

When Content is displayed, a small image of the far end conference participants appears alongside the larger Content image, layouts may be altered using the Layout button.

Content transmitted or received

1.   Content big, far site small
2.   Content big, near site small
3.   Content and far site, same size, side by side
4.   Content, full screen
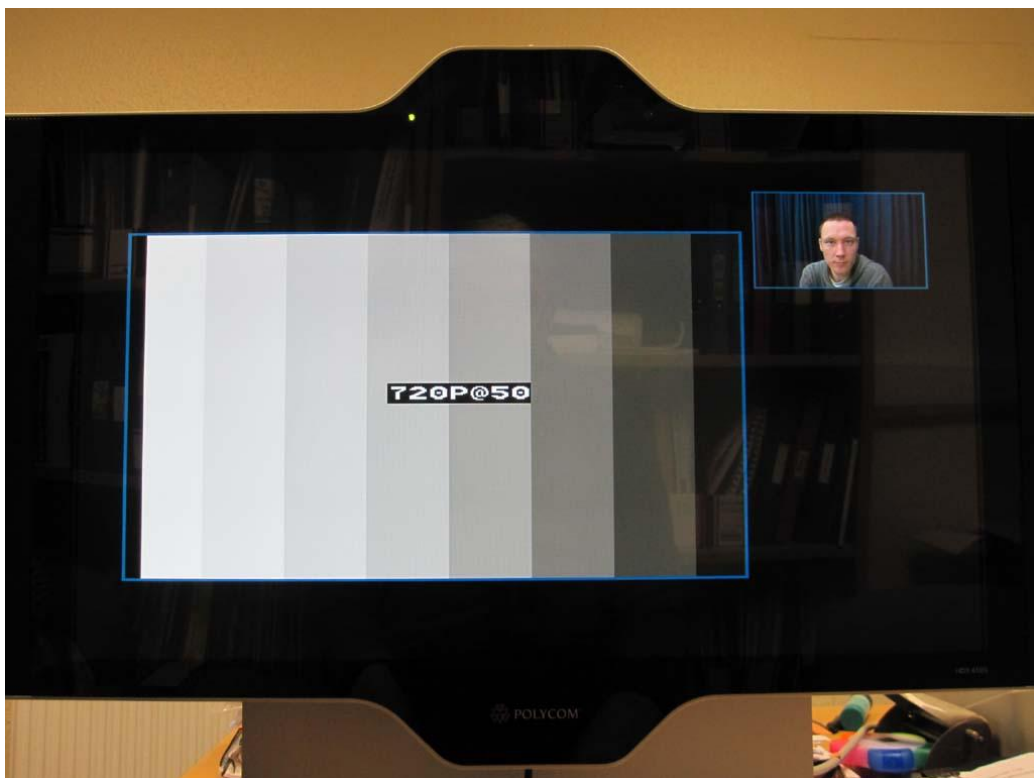
Point to Point Call, Picture outside Picture (POP) with 16x9 Content

In dual monitor mode with no Content transmitted or received the main monitor displays the far site image and system menus, the second monitor displays the near site camera images.

When content is transmitted a number of layout options are available.

Main Monitor (includes Menus)	Second Monitor
Content and near site, same size, side by side	Far site full screen
Content big, near site small	Far site full screen
Content big, far site small	Near site full screen
Content full screen	Near site full screen
Content full screen	Far site full screen

When Content is received a number of layout options are available.

Main Monitor (includes Menus)	Second Monitor
Far site big, near site small	Content full screen
Near site big, far site small	Content full screen
Near and far sites, same size, side by side	Content full screen
Far site full screen	Content full screen

The Polycom® high definition camera has a native resolution of 1920 x 1080 (1080p) it has a fixed focus lens and tilts with the monitor adjustment. A 2x digital zoom is available but unlike an optical zoom its use just degrades the image. A manual privacy shutter control is provided above the camera.

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 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.

The optional high definition MCU provides four (host HDX CODEC plus three 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. The MCU option was not available on the evaluation systems.

During an H.323 call a second unidirectional video channel (Content) is provided through H.239, "People" being the normal conferencing channel. Thus video from the camera and a second source e.g. a PC image could be transmitted simultaneously and displayed on two monitors at the remote site. For People and Content the bandwidth may be dynamically 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.

The HDX system is capable of transmitting and receiving two simultaneous high resolution (1080p at 30fps) images. The high definition high frame rate Content channel is a new development that enhances the overall conference experience.

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 the two monitor microphones to create a stereo image.

A separate stereo audio input using a 3.5mm mini jack connector allows for straightforward interfacing to a PC or laptop. A useful feature mutes Content audio on the local and remote loudspeakers until Content is selected for transmission.

Unfortunately not many other manufacturers provide this facility. Additionally when the PC image is previewed its associated audio is only heard at the local site. Echo cancellation is appropriately disabled on this input.

System control is normally through the wired remote but if preferred a Polycom standard infra red control may be used. Remote configuration is another option via a web browser from a network connected PC. This comprehensive web interface provides control and configuration of the CODEC and displays diagnostic information if required, together with web snapshots of near and far sites. For added security this remote management system may be password protected. For connection to a room control system etc. an RS232 serial control port is also provided.

D: SYSTEM OPERATION

The remote control panel includes dedicated controls for Dial, Hang up, Directory, Volume, Microphone mute, Zoom, Near/Far and Layout together with cursor controls to navigate the on screen menus.

The Content (PC) input signal is controlled via two buttons. The monitor preview button cycles between the PC input and the CODEC output, while the second button transmits or stops transmission of the PC image over the conference link to the remote site(s)

The 'Info' button has dual functions, providing context sensitive help when not in a call and a shortcut to Call Status information during a call.

HDX 4500 Remote Control Panel

The PC input source to the HDX CODEC must be designated either "People" or "Content". People images are transmitted on the main video channel while Content images are transmitted on the second H.239 video channel. When presentation (Content) material is transmitted or received the system maintains the main (People) channel resolution despite the reduction in bandwidth allocated to that channel. If it is desired to allocate all the call bandwidth to the Content to maximise image quality, then the Content (PC) signal may be connected to the main channel.

Network connection of a PC to the CODEC is also possible by loading the software application "People + Content™ IP" onto the PC or laptop, but this is limited to visual material only as sound is not transmitted.
An H.239 (dual video) conference is initiated and terminated by pressing the "Send Computer" button on the remote control panel. The camera occupies the first channel and the PC image source the second channel. The two signals are then sent to the remote site for simultaneous display on two picture monitors. Both channels can deliver high resolution high frame rate images.

Successful H.239 conferences were established in both directions between HDX systems and with other manufacturers' CODECs for both high and ordinary definition conferences. The HDX 4500 CODEC supports remote camera control.

The system takes just over 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 remote control panel button press will return the system to active mode.

Some problems were experienced after re-booting the system. Several user system settings had returned to the default from their original user selection, these included: Camera white balance and second monitor screen resolution. This could cause problems for casual users as it occurred after a power off and/or a reboot.

At times some areas of the menu were "greyed out" (i.e. could not be selected) suggesting that the CODEC was in a call, when in fact it was not. The problem could only be cleared by re-booting the system.

Web Interface Screen Shots:

Call Status

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.

Remote Monitoring

Web Director

Screenshots reproduced by permission of Polycom®

E: VIDEO TESTS SUMMARY

High Definition Image Quality

Unfortunately, during testing the cameras at both sites appeared to have faults that limited the image quality. In calls between HDX 4500 systems one camera produced soft focus images with a very limited depth of field. The other camera produced more acceptable results but the edges of objects in the image appeared artificially sharp whereas areas of fine detail, for example hair and skin texture appeared blurred and with too much contrast (Posterised).

When Content material from a PC was transmitted on either channel the results were good, suggesting that the problems experienced were camera related as opposed to CODEC or picture monitor issues.

The ability to send and receive two high resolution, high frame rate images was seen as a very positive feature.

F: AUDIO TESTS SUMMARY

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

Audio levels adequate? (Yes/No)	Yes
Audio quality acceptable? (Yes/No)	Yes
Echo cancellation acceptable? (Yes/No)	Yes
Quality of double talk	Excellent

When the frequency response was measured it was found to be quite uneven for all audio protocols. The levels measured 0 dB at both 1KHz and 7 KHz but at mid-band (i.e. 3.5 KHz) was -6dB indicating a notch in the frequency response between these frequencies.

G: DATA TESTS

A PC may be directly connected to the CODEC via the DVI interface and may be transmitted on either the main channel or the H.239 channel. Audio from a PC may only be transmitted when the PC is selected on the main channel. People + Content™ IP software may also be used to connect a PC to the CODEC across the data network but with picture only

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 manufacturers' 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)

H.323

Successful connections were made in each direction with the following CODECs, where the systems supported H.239, presentation material was also shared.

CODEC Model and Software Version	Call Bandwidth	Resolution Transmitted by the HDX 4500	Resolution Received by the HDX 4500
Polycom PVX S/W 8.0	1.5 Mbit/s	352 x 288	320 x 240
Polycom® VSX7000 S/W 9.0.5.1	2 Mbit/s	352 x 288	352 x 288
Tandberg Edge 95 S/W F9.0 PAL	2 Mbit/s	352 x 240	352 x 288
Tandberg 6000 MXP S/W F9.0 PAL	2 Mbit/s	704 x 576	720p
Tandberg C40 S/W TC4.0.1	2 Mbit/s	1080p	720p
Tandberg C60 S/W TC3.1.1	2 Mbit/s	1080p	720p
Polycom HDX 9002 S/W 2.6.0	2 Mbit/s	720p	720p
Lifesize Team S/W 4.7.10	2 Mbit/s	720p	720p
Lifesize Room 200 S/W 4.7.0	2 Mbit/s	720p	720p

In calls between the HDX4500 and Tandberg Edge 95 low resolution CIF was transmitted by the Tandberg and SIF was transmitted by the HDX4500.

In calls between the HDX4500 and Tandberg 6000 MXP the HDX4500 transmitted 4CIF.

Resolution in pixels and their common designation:

- 1920 x 1080   1080p
- 1280 x 720   720p
- 1024 x 576   W4CIF
- 704 x 576   4CIF
- 576 x 448   448p
- 512 x 288   WCIF
- 352 x 288   CIF
- 352 x 240   SIF
- 320 x 240   QVGA

Connectivity with Janet Videoconferencing Switching Service (JVCSS)

The HDX connected to the Codian MCU using H.264 Video and G.722.1 audio in both directions. It interoperated successfully also negotiating 720p resolution on the H.239 channel.

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

Procedure for making a call

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

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) 75 x 53 x 21 cm

Video Inputs	Format	Connector
Main camera	Internal connection	
PC input	VGA, DVI, Component	DVI-I

Video Outputs	Format	Connector
Main monitor	Internal connection	
Second monitor	VGA, DVI, Component	DVI-I

Audio Inputs	Level	Connector
HDX microphones	Internal connection	3.5mm mini jack
PC audio input	Line	

Audio Outputs	Level	Connector
Monitor	Internal connection	Both RCA Phono
Loudspeakers		
Main audio output	Line	

Data
1. 1 off LAN 10/100 Mbits/s Ethernet connection (RJ45)
2. 1 off 9 pin RS232 serial control
3. 1 off USB connector (to enable software updates)

Cables Supplied

1.   1 off 1.5 metre, VGA-DVI cable
2.   1 off 1.5 metre, DVI-DVI cable
3.   1 off 1.5 metre mini jack – mini jack
4.   1 off 3.6 metre RJ45-RJ45 network cable
5.   1 off IEC power cord

Mobility

The Polycom® HDX 4500 system can be moved easily. To establish a connection, each new location will need the local area network information re-entered into the configuration menu.

Appendix 2 Detailed Video Tests

The HDX system supports, H.261, H.263, H.263+ and H.264, but these protocols are automatically selected. In calls between HDX units only the default protocol H.264 could be tested as this was the one negotiated by the CODECs

For the following tests using the DVI input and with the PC input set to People and Sharpness, the video resolution between HDX systems was 4SIF at 384Kbit/s rising to 720p at all other connection speeds

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	**OP**
(lagging images from previous frames as faded or outline images)	
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)

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)

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)

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	2	1	1	1
BLR	2	2	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	2	1	1	1
BLK	3	2	1	1
BLR	3	2	1	1
CLR	1	1	1	1
JRK	2	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	3	1	1	1
BLR	3	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	4	2	1	1
BLR	4	3	2	2
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	3	1	1	1
BLR	3	2	1	1
CLR	1	1	1	1
JRK	2	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	3	1	1	1
BLR	3	2	1	1
CLR	1	1	1	1
JRK	2	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	1	2	1	1
CLR	2	1	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	2	1
CLR	2	2	1	1
JRK	2	2	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	3	2	1	1
BLR	3	2	2	2
CLR	2	2	2	1
JRK	3	2	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	1	1
BLR	3	3	3	3
CLR	2	2	2	1
JRK	4	3	2	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	3	2	1
BLR	5	4	2	2
CLR	2	2	2	2
JRK	2	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	2
BLR	4	3	2	2
CLR	1	1	1	1
JRK	4	3	2	1

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	3	2	2	1
BLR	3	2	2	1
CLR	1	1	1	1
OP	1	1	1	1
SCR	3	2	2	2
JRK	3	2	2	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

As there is no analogue video input this test could not be carried out.

Appendix 3 Detailed Audio Tests

Note: In tests between HDX 4500 units it was not possible to select audio protocols so only a limited range could be tested.

Test 1: Frequency response (-3 dB)
(Insert -6 dB signal at local site, measure at remote site)

Siren LPR	Siren LPR Stereo	Siren LPR Stereo	Siren LPR Stereo
24Kbit/s	48Kbit/s	96Kbit/s	128Kbit/s
12 KHz	12 KHz	14 KHz	22 KHz

When the frequency response was measured it was found to be quite uneven for all audio protocols. The levels measured 0 dB at both 1KHz and 7 KHz but at mid-band (i.e. 3.5 KHz) was -6dB indicating a notch in the frequency response between these frequencies.

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: +3 dBm

Test 3: Audio level
(Insert 0dBm 1KHz tone at local site, monitor the received level at the remote site)

As the audio output is varied by the volume control this test could not be carried out.

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.

Audio levels adequate? (Yes/No)	Yes
Audio quality acceptable? (Yes/No)	Yes
Echo cancellation acceptable? (Yes/No)	Yes
Quality of double talk	Excellent