TANDBERG television

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USER GUIDE

EN5990 HD Encoder for
MPEG-4 Part 10 (H.264/AVC)

Software Version 3.0 and later

EN5990/BAS
EN5990/BAS/48V

EN5990 Encoder

ENGLISH (UK)

www.tandbergtv.com

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1 Who Should Use This User Guide?

This User Guide is written for operators/users of the EN5990 Encoder to assist in installation and operation. It is not intended to be a detailed source of information. This can be found in the *Reference Guide* companion document, which is issued on CD.

WARNING

Do not remove the covers of this equipment. Hazardous voltages are present within this equipment and may be exposed if the covers are removed. Only TANDBERG Television trained and approved service engineers are permitted to service this equipment.

CAUTION

Unauthorised maintenance or the use of non-approved replacements may affect the equipment specification and invalidate any warranties.

1.1 What Equipment is Covered by This User Guide?

Table 1.1: Equipment Model Descriptions

Model Number	Marketing Code	Description
EN5990 Encoder	EN5990/BAS	Premium 2RU Encoder supporting H.264/AVC HD video encoding for low bitrate applications.
EN5990 Encoder (-48 Vdc version)	EN5990/BAS/48V	EN5990/BAS Encoder with -48 Vdc input

1.2 Hardware and Software Options

See *Table 1.2* for a list of hardware options and *Table 1.3* for a list of software options available with the Encoder. Detailed information is in the *Reference Guide*.

Table 1.2: Hardware Options

Marketing Code	Description
EN5900/HWO/IPTS	IP Network Interface Card that enables transport stream output over an IP/Ethernet network. Single 10/100BaseT output. Has been superseded by the IPTSDUAL card.
EN5900/HWO/IPTSDUAL	Replacement for previous option card that has 2 separate IP/Ethernet ports and can interface to GigE network.

Table 1.3: Software Options

Marketing Code	Description
EN5900/SWO/AC3	Allows the audio input to be encoded using the Dolby AC-3 encoder.
EN5900/SWO/BISS	Allows the output transport stream to be scrambled using the Basic Interoperable Scrambling System (BISS) with a operator defined key.
EN5900/SWO/MPEG2/AAC	Allows the audio input to be encoded using MPEG-2 AAC LC profile, encapsulated with ADTS.
EN5900/SWO/MPEG4/HEAAC	Allows the audio input to be encoded using MPEG-4 HE-AAC profile, encapsulated with LAOS/LATM.
EN5900/SWO/NR	Allows the pre-processor to enable a noise filter on the incoming video source.
EN5900/SWO/RAS	Enables Remote Authorization System which is a proprietary public-key encryption system to prevent unauthorized viewing of a TV program.
EN5900/SWO/REFLEX	Allows the encoder to be a part of an reflex multiplexor group.

1.3 Summary of HD MPEG-4 Encoder

The MPEG-4 HD Encoder is a professional-grade Encoder for highly efficient H.264/AVC video encoding and MPEG-4 audio encoding. It delivers unsurpassed compression performance in real-time for broadcast applications.

The product is based on technology and knowledge gained over ten years and six generations of MPEG video and audio developments. The dedicated hardware and software implementation gives consistently the very best real-time quality at the very lowest possible bitrates.

1.3.1 Video Encoder

The Encoder compresses a high definition video signal into an encoded bitstream for broadcast transmission in accordance with the ISO/IEC-14496-10 standard, also known as H.264/AVC.

Pre-processing features include noise-reduction filters, video resizing and de-interlacing. More details are given in *Section 5*.

1.3.2 Audio Encoder

The Encoder can handle multiple audio services to accompany the video component, including:

- The ability to pass thru pre-compressed Dolby Digital bitstreams with the option of glitch suppression.

- Compression of stereo and 5.1 audio services using algorithms such as MPEG-2 AAC-LC, MPEG-4 HE-AAC, Dolby AC-3® or MPEG layer II. The operator can define the language descriptor associated with each service.

1.3.3 Encapsulation Methods

The video and audio bitstreams are multiplexed into a compliant MPEG-2 transport stream enabling the transmission over existing MPEG broadcast infrastructure (or optionally transport over IP).

2 Installing the Equipment

2.1 Introduction

CD For best performance and reliability, follow the instructions for site requirements and installation in the *Reference Guide* and only use installation accessories recommended by the manufacturers.

2.2 Operating Voltage

CAUTION

This product should be operated only from the type of power source indicated on the marking label. If you are not sure of the type of power supply to your business, consult a qualified electrical engineer or your local power company.

NOTE

Refer to the *Reference Guide* for details of the colour codes used on the mains leads.

CD See *Table 2.2* for fuse information and also the *Reference Guide* for a full power supply specification.

A.C. Models

A.C. models are fitted with a wide-ranging power supply. It is suitable for supply voltages of 100-120 Vac -10%/+6% or 220-240 Vac -10%/+6% at 50/60 Hz nominal.

-48 Vdc Models

Model EN5990/BAS/48V uses a –48 Vdc power supply.

2.3 Power Cable and Earthing

Check that the power cable is suitable for the country in which the Encoder is to be used.

WARNINGS

1. The Technical Earth is not a Protective earth for electric shock protection.
2. This unit must be correctly earthed through the moulded plug supplied. If the local mains supply does not have an earth conductor do not connect the unit. Contact Customer Services for advice.
3. Before connecting the unit to the supply, check the supply requirements in Annex B of the Reference Guide.

2.4 Power Supply Stand-by Switch

This switch puts the Encoder into stand-by mode. It powers down the supply rails of the display and internal circuits within the unit. The switch type avoids accidental powering-down of the Encoder. For normal use, using a screwdriver, ensure that the **I** is always at the top (see *Figure 2.1*).

WARNING

This is NOT a mains switch and will not isolate the Encoder from the power supply. Disconnect the power cord to isolate the unit.

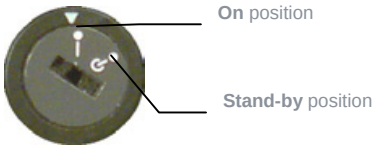

Figure 2.1: Stand-by Switch

2.5 Connecting Up the Encoder

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Always use the specified cables supplied for signal integrity and compliance with EMC requirements (see *the Reference Guide*).

The connectors illustrated in *Figure 2.2* and described in *Table 2.1* are active.

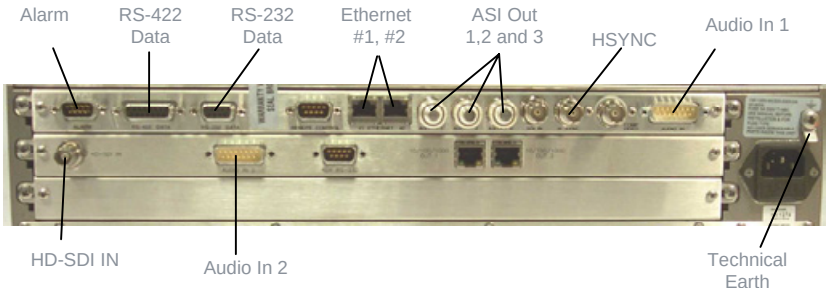


Figure 2.2: Rear Panel Component Parts and Connectors

Table 2.1: Types of Connector

Type of Connector	Description
Alarm	If required, connect an external status-monitoring device to the **Alarm** connector. A 9-way, D-type male connector provides an alarm relay interface.
RS-422/RS-232 Data	Both the 15-way D-type female connector and the 9-way D-type female connector for RS-232 can be used for the entry of real-time data such as closed captioning information.
Ethernet #1 and #2	An 8-way, RJ-45 connector provides a 10BaseT Ethernet interface for control and monitoring. The Encoder has a single switched Ethernet channel. Ethernet#1 is selected as default at power up. If a carrier is not detected on Ethernet#1 then the input switches to Ethernet#2.
ASI OUT 1, 2 and 3	A 75 Ω BNC connector provides the transport stream output from the Encoder, if this feature has been enabled.
HSYNC	A 75 Ω BNC connector allows the internal encoder clock to be locked to a reference.
Audio In 1	The 15-way, D-type male connector is available for legacy audio encoding. It is recommended that it is not used so o cable is supplied with the unit for use with this connector.
Technical Earth	Connect the Encoder's Technical earth to a suitable point.
HD-SDI IN	A 75 Ω BNC connector provides a high definition serial digital video input to the unit.
Audio In 2	The 15-way, D-type male connector that allows the input of up to 4 stereo pairs of digital audio into the unit. A **breakout cable** is supplied as part of the basic unit.

NOTE

Refer to the *Reference Guide* for all power supply, fuse, safety, EMC information and operating conditions.

2.6 Connecting the Encoder to the Power Supply

WARNINGS

1. Do not overload wall outlets and extension cords as this can result in a risk of fire or electric shock.
2. As no mains switch is fitted to this unit, ensure the local power supply is switched OFF before connecting the supply cord.
3. The Encoder is not fitted with an on/off switch. Ensure that the socket-outlet is installed near the equipment so that it is easily accessible. Failure to isolate the equipment properly may cause a safety hazard.

Connect the Encoder to the power supply as follows:

- **Power Supply**
  Ensure the power supply is isolated and switched off.
- **Encoder**
  Ensure the correct fuse type and rating has been fitted to both the equipment and the power cable.
- **Supply Cord**
  Connect the lead to the Encoder input connector and then to the power supply. Switch on the power supply.

Table 2.2: Fuse Type and Rating

Power Supply	Fuse Type and Rating
100-120 Vac / 220-240 Vac	Bussmann S505/Littelfuse 215, 5 A 250 V T HBC
-48 Vdc	Bussmann S505/Littelfuse 215, 6.3 A 250 V T HBC

3 Operating the Equipment From the Front Panel

3.1 Introduction

The front panel display and keypad may be used to configure, control and monitor the Encoder when an external control system is not used.

3.2 Establishing Local Control

At power-on the Encoder runs through a boot sequence where the operation of different modules within the Encoder are checked. The time taken for the unit to boot is between one and two minutes.

After this process, the Encoder displays the summary screen and the operator can access the menus from the front-panel or use a web browser once the remote control IP address has been set correctly.

3.3 Navigating the Menus

3.3.1 Navigation Keys and Buttons

The front panel of the Encoder can be operated according to *Figure 3.1*. The operation of the individual keys is described in *Figure 3.2*.

Each softkey on each side of the display is used to access, select and sometimes amend the menu item associated with it.

Where there is a +/- sign associated with a softkey, this scrolls through a set of options.

This keypad is used to amend the menu option which has been selected (unless indicated otherwise).

Figure 3.1: Keypad and Display Functions

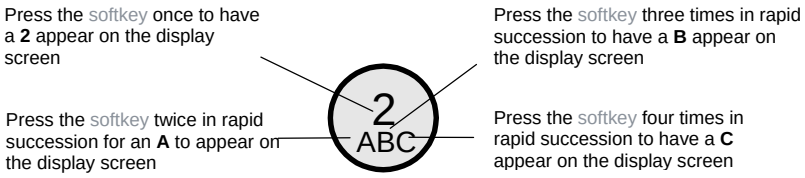


Figure 3.2: Accessing Inscriptions on the Keypad

3.3.2 Typical Display During Operation

The following display screens show the different functions associated with the options.

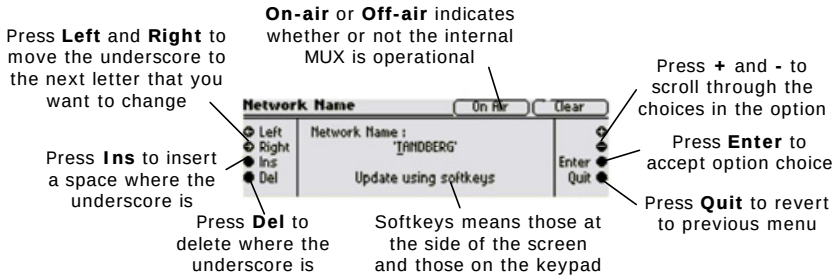


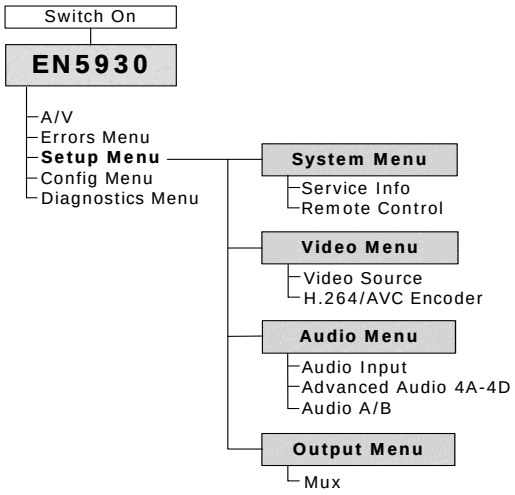
Figure 3.3: Functions Associated With Softkeys

The softkeys can be locked out to prevent inadvertent operation and the key icon will be displayed. Press the softkey adjacent to the key icon. This shows the **Keyboard Lock** screen. Press the **Yes** softkey to disable the softkeys. They are all disabled with the exception of **Unlock**. To enable and restore the softkey functions, press the **Unlock** softkey. This shows the **Keyboard Lock** screen. Press the **Yes** softkey.

NOTE

A black diagonal cross enclosed by a white circle (⊗) means that the Encoder is under remote control and the user does not have access to change that parameter.

4 Typical Operation and Setting of Parameters



NOTE

This is a partial menu structure, indicating those menus used in the following sections.

Figure 4.1: Menu Structure

CD

Refer to the following steps for a typical set up. See *Figure 4.1* for the menu structure and *Section 4.1* onwards on how to navigate the menus. For more detailed information or parameters not mentioned refer to the *Reference Guide*.

- Set the remote control options.
- **Optional**: control the Encoder using a web browser.
- Set the output connection options.
- Set the video input options.
- Set the audio input options (for both sets of channels if necessary).
- Set service information.

4.1 Set the Remote Control Options

Before the Encoder is to be controlled via its Ethernet interface, the IP address of the unit must be set in the `Remote Control Menu` from the front panel.

Navigate to the `Remote Control Menu`. Select the following option:

- **IP Address** – enter/modify the IP address through which the unit will be controlled.
- **Network mask** – enter/modify the network mask for the IP control network.
- **Default Gateway** – enter/modify the default gateway for the network so that the Encoder can be controlled from another network.

4.2 Control the Encoder Using a Web Browser

If the web browser is pointed to the IP address set in the previous Section, the Encoder will serve out web pages which gives the operator user-friendly access to all of the menu options.

As there are security issues with remote control of the Encoder, the following information is required before the Encoder allows any options to be modified:

- Username: engineer
- Password: defaults to “password” but it can be changed from within the System menu.

4.3 Select Mux Options

All of the options associated with the output connections are set with the `Output Menu` and then `Mux`. The typical options that should be checked by the operator are:

- **Packet Length** – enter/modify the length in bytes of each transport stream packet.
- **Bitrate** – enter/modify overall output rate of total MPEG-2 transport stream including video, audio and NULL packets.

4.4 Set the Video Options

Navigate to the `Video Menu` and select the `Video Source Menu` to configure the video input to the Encoder. Select the following options:

- **Video Input** – select the HD-SDI video input in terms of frame rate and resolution required. If desired, the Encoder can detect the input frame rate automatically and adjust the encoding accordingly (see the *Reference Guide* for details).
- To modify some individual parameter value from that of the selected operating scenario, exit the `Video Source Menu` and select the `H.264/AVC Encoder Menu`. The menu lists all of the parameters that can be changed by the operator, including:
  - **Mode** – select the mode to determine the decoder buffer size.
  - **Bitrate** – select the desired maximum bitrate from the video encoder. This is constrained so that the maximum total bitrate for the whole bitstream is not exceeded.
  - **Resolution** – select the resolution of the decoded video image. The use of this parameter is discussed in *Section 5.1*.
  - **GOP Length** – select the maximum number of frames between consecutive I-frames. This value can be varied between 1 and 180 frames. The video encoder may choose to use I-frames more frequently if the content requires it.
  - **PID** – defines the program identification number for the H.264/AVC elementary stream in the transport stream.

4.5 Set the Audio Options

The audio menus consist of a set of audio service menus (4A – 4D, A and B). The services A and B are associated with the generic architecture and have limited operations. Each service menu allows the operator to define the input source and type. The input type (currently limited to uncompressed or compressed AC-3) defines what encoding can be performed on that service. The remainder of the service defines the encoding parameters and the associated language.

4.6 Set Service Information

Navigate to the `System Menu,` and then `Service Information` to modify this information. This sets the name on the front panel. The bitstream carries some self-descriptive information that can be displayed on many of the decoders.

5 Frequently Asked Questions

5.1 How to Define the Bitrate?

There are several bitrates involved with the operation of the Encoder:

- Transport System (TS) bitrate: this is defined in the `Output/Mux Menu` and defines output rate of the TS packets
- The bitrates for the output of each underlying module including video and audio.

The recommended method to set the bitrate:

- Set the Transport Stream bitrate: this is set first as it is normally defined by an external parameter such as bandwidth of the DSL network or the bandwidth of the satellite transponder.
- Set the audio bitrate: choose the value that corresponds to the minimum acceptable broadcast quality. For MPEG-1 Layer II, this is typically 192 kbit/s for a stereo pair. For MPEG-2 AAC, this is typically 96 kbit/s.
- Set the video bitrate to be the maximum allowed. The Menu system restricts the video bitrate so that the total bitrate of all of the modules does not exceed the Transport Stream bitrate.

The encoder implements a compression mode called “Capped VBR” where VBR denotes Variable bitrate. This means that the rate control for the video will ensure that the short-term (measured over the period of the video decoder buffer) video bitrate will not exceed the value defined by the operator. The video encoder does not add any padding to the video stream and so it will not deliver constant bitrate (CBR).

5.2 Video Quality Versus Bitrate Versus Channel Switching

The implementation of H.264/AVC algorithm used for the EN5990 has been optimised to produce broadcast quality video at very low bitrates. However there are bitrates below which the algorithm cannot maintain broadcast quality. It should be remembered that the cut-off bitrates involved depend on the content being encoded. For example, sports content requires more bits to encode than the image of a newsreader to achieve the same visual quality.

However, in broadcast systems, the time taken to switch between two television channels needs to be kept below a maximum value. The two requirements, quality and switch time, work against each other in that setting parameters to improve video quality will generally increase channel-switching time. The values of the following parameters can be modified to achieve different compromises between video quality, bitrate and channel switching:

- **Resolution Reduction**: the horizontal resolution of the image can be reduced from the full resolution of the input to lessen the information in the image and hence the number of bits required to encode it. This has no effect on channel switch time.
- **Mode**: This defines the size of the decoding buffer used by the encoder to to allow short-term variations in bitrate to give better quality at constant bitrate. Choosing a long delay will increase the ability of the video encoder to handle difficult material. However, as the buffer exists partially in the receive device, when a channel is switched, the incoming stream associated with the new channel must be buffered for this time before the decoding process can start. So choosing a long delay will increase channel switch time.
- **GOP Length**: as the I-frames require many more bits than other frame types, reducing the number of I-frames per unit time reduces the total number of bits. Hence, a longer GOP (group-of-pictures) length can allow a lower bitrate. However, the decoding process can only start with an I-frame, as the appearance of all other types of frames is dependent on the previous I-frame. Thus, increasing the GOP length will increase the average time for the I frame to arrive and so the average channel switch time.

5.3 Why Does the Transport Stream Analyser Show Fluctuating Bitrate for the Video PID?

If the `Compression mode` is set to `Capped VBR`, the video encoder does not implement constant bitrate encoding but capped variable bitrate as described in *Section 5.1*. The bitrate does not exceed a maximum bitrate defined in the `H.264/AVC Video Encoder Menu`. However if the encoding quality is sufficiently high, then the encoder does not attempt to maintain the maximum bitrate. This can be useful in the scenario where there are other services that require to use the IP bandwidth.

5.4 How can the End-to-End Latency of the System be Reduced?

It is important to note that decreasing the end-to-end latency will have a detrimental effect on the encoding efficiency and hence, the video quality will be decreased for the same bitrate. The end-to-end latency consists of:

- **Latency Associated with the Video Pre-processing within the Encoder** - the Encoder was designed to minimise this so no major reduction can be made by changing the parameters for the pre-processing module.
- **Latency Associated with the Actual Video Encoding** - this is dominated by the option chosen in the Mode menu item. Choosing “Mega Low Delay” will give the lowest latency.

- **Latency associated with the transmission medium and decoder** - this cannot be varied by any of the other parameters associated with the Encoder.

5.5 How do I Transmit Transport Stream over an IP Network?

The product has an optionally fitted card that can output the internal Transport Stream (TS) over an IP/Ethernet network. This option can be purchased as part of the unit with the marketing code EN5900/HWO/IPTS.

The card implements RFC 2250, which specifies the carriage of MPEG-2 TS over IP using unicasting or multicasting. DVB-IPI has enhanced the reliability of the UDP transmission by defining a forward error correction (FEC) scheme to handle the loss of IP packets without loss of the underlying TS. More detail on the operation of this card is given in the *Reference Guide*.

Alternatively an external IP streamer or ASI adapter can be used. A range of suitable products is available from TANDBERG Television.

5.6 Why are There no IDR Pictures in the Video Stream?

An IDR (instantaneous decoding refresh) picture is a type of I picture which states that no picture after the IDR may reference a picture prior to the IDR. An IDR can always be used for random access into a stream, however it is possible and desirable to have random access points which are not IDRs. The reason for this is that if every random access point is an IDR, it would restrict the way in which B frames could be used. Consider a random access I picture which has an associated B frame that follows it, in encode order, but precedes it in display order. This I picture cannot be an IDR as the B picture following it references pictures prior to it. However this I picture is still a valid random access point as no picture following it in display order ever references a picture preceding it.

All I pictures from TANDBERG TV encoders can be used for random access, this is signaled by the Random Access Indicator flag in the Adaptation Field of the video transport stream packet. When this flag is set, there will be a PES header starting at that packet and the decoder can start to decode the video stream. The presentation time stamps of the following frames need to be monitor to ensure that the following B frames are not displayed.

If this is still not sufficient for the decoder, there is a menu switch in the video encoder menu which forces the video encoder to switch off B frames at the end of each GOP so that the I frame can be identified as an IDR. This is at the expense of video encoding quality.

5.7 What Parameter Values Should be Used to Optimise Video Quality?

The parameters discussed in *Chapter 4* are the most important parameters for the operation of the encoder and these parameters should be set initially. However there are other parameters that can be used to further optimise the video quality.

Video quality can be optimised for two mutually exclusive scenarios:

- Viewing by human subjects called subjective quality testing: where it is important that the coding artefacts are not annoying.
- Analysis by computer called objective quality testing: where the coded video must be as close as possible to the original video source.

The recommended parameter values are shown in *Table 5.1*.

Table 5.1: Recommended Values for the Different Video Parameters

Parameter	Objective	Subjective
Noise reduction	Off	Adaptive 1
Bandwidth	Sharp to medium	Medium to soft
Adaptive QP	Off	On

5.8 Why are the Audio and Video Presentation Time stamps so Different?

In some configurations, the presentation time stamps associated with audio and video frames that are located at a similar time in the Transport Stream can differ by several seconds. This causes problems for the decoder if either the video or audio time stamp is used as a clock reference.

This difference in time stamp is valid as the decoder is required to have a much larger video buffer than audio buffer. For most audio standards such MPEG-2 AAC, the buffer is less than 1 second while the H.264/AVC video buffer for SD applications is 10 Mbit/s. To obtain the optimal video quality overall, the encoder varies the number of bits allocated to each frame dependent on a large number of parameters. This means that for a 2.0 Mbit/s video rate, the presentation time stamp of the video frame can vary from the system clock to 5 seconds ahead of the system clock. The difference associated with audio will always be less than 1 second so there could be up to 4 seconds difference between the audio and video time stamps. An example is shown in *Figure 5.1.*

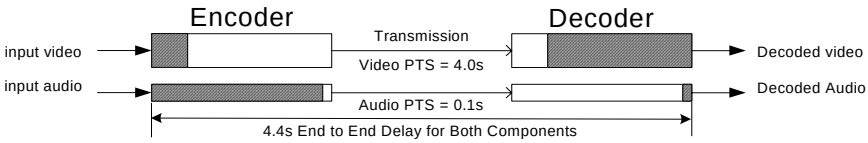


Figure 5.1: Time stamp Structure for Video and Audio

The decoder could use the audio time stamps as the timebase to determine how much video to buffer before decoding the frames. However the audio will still vary by some 100 milliseconds causing lipsync issues. The correct timebase to use in the decoder for referencing the presentation and decoding time stamps is the system clock as indicated by the PCR (program counter reference) values in the Transport Stream. The PCR values represent a very accurate clock reference from a stable temperature-controlled oscillator within the encoder and hence, will be more accurate than any clock system in a consumer decoder.

5.9 Why are there Referenced B Pictures?

With MPEG-4 H.264/AVC, B pictures contain extra tools, which allow them to be coded more efficiently. The detail is that the prediction modes available to generate data within a B picture, from multiple reference frames, represent a superset of the modes available to a generate P picture, from a single reference frame. One such mode is “Direct Mode” where the motion vector is estimated from the equivalent motion vectors of the reference frame and minimal additional information is required.

Hence the number of bits required to encode B pictures is significantly less than P pictures. This has led to the development of referenced B pictures, which are pictures that are generated as B pictures so use fewer bits than an equivalent P picture but can be used as references for other B pictures. Thus, fewer bits are required to encode the same sequence to the same quality level. The technique is called hierarchical B pictures as a hierarchy of B pictures is created. The application of this technique has several implications:

- The encoding quality for the same bitrate improves dramatically for still and low motion sequences. The encoder monitors the amount of motion and seamlessly adapts the number of B pictures accordingly to obtain optimal efficiency.
- Due to the increased number of B frames, the time distance between P pictures is larger with an accompanying increase in the coding delay.
- As such, the difference between the DTS and PTS of the P frames is larger than with the traditional GOP structure.

6 Equipment Packaging

6.1 Packaging Statement

The outer carton and any cardboard inserts are made from 82% recycled material and are fully recyclable.

The Stratocell ® or Ethafoam 220 ® polyethylene foam inserts can be easily recycled with other low density polyethylene (LDPE) materials

6.2 Packaging Markings

The symbols printed on the outer carton are described below:

Handle with care

This way up

Fragile

Protect from moisture

See *Reference Guide* for details of compliance with directives details.

See *Reference Guide* for details of compliance details

Defines country of origin.

The packaging is reusable per GB 18455-2001

This symbol guarantees that packaging with this symbol is recyclable and will be accepted by cardboard recyclers

Recyclable per GB 18455-2001

7 Materials Declarations

7.1 Overview

TANDBERG Television products are designed and manufactured in keeping with good environmental practise. Our component and materials selection policy prohibits the use of a range of potentially hazardous materials. In addition, we comply with relevant environmental legislation.

7.2 For the European Union

For product sold into the EU after 1st July 2006, we comply with the EU RoHS Directive. We also comply with the WEEE Directive.

7.3 For China

For product sold into China after 1st March 2007, we comply with the "Administrative Measure on the Control of Pollution by Electronic Information Products". In the first stage of this legislation, content of six hazardous materials has to be declared together with a statement of the "Environmentally Friendly Use Period (EFUP)": the time the product can be used in normal service life without leaking the hazardous materials. TANDBERG Television expects the normal use environment to be in an equipment room at controlled temperatures (around 22°C) with moderate humidity (around 60%) and clean air, near sea level, not subject to vibration or shock.

Where TANDBERG Television product contains potentially hazardous materials, this is indicated on the product by the appropriate symbol containing the EFUP. For TANDBERG Television products, the hazardous material content is limited to lead (Pb) in some solders. This is extremely stable in normal use and the EFUP is taken as 50 years, by comparison with the EFUP given for Digital Exchange/Switching Platform in equipment in Appendix A of "General Rule of Environment-Friendly Use Period of Electronic Information Products". This is indicated by the product marking:

It is assumed that while the product is in normal use, any batteries associated with real-time clocks or battery-backed RAM will be replaced at the regular intervals.

The EFUP relates only to the environmental impact of the product in normal use, it does not imply that the product will continue to be supported for 50 years.

8 Disposal of this Equipment

8.1 General

Dispose of this equipment safely at the end of its life. Local codes and/or environmental restrictions may affect its disposal. Regulations, policies and/or environmental restrictions differ throughout the world. Contact your local jurisdiction or local authority for specific advice on disposal.

8.2 For the European Union

"This product is subject to the EU Directive 2002/96/EC on Waste Electrical and Electronic Equipment (WEEE) and should not be disposed of as unsorted municipal waste."

9 Recycling

TANDBERG Television provides assistance to customers and recyclers through our web site http://www.tandbergtv.com/ProductRecycling.ink Please contact TANDBERG Television's customer services for assistance with recycling if this site does not show the information you require.

Where it is not possible to return the product to TANDBERG Television or its agents for recycling, the following general information may be of assistance:

- Before attempting disassembly, ensure the product is completely disconnected from power and signal connections.
- All major parts are marked or labelled to show their material content.
- Depending on the date of manufacture, this product may contain lead in solder.
- Some circuit boards may contain battery-backed memory devices.

10 Lithium Batteries

This equipment uses a single Lithium battery to allow an internal real-time clock to continue operating during periods when the unit is powered down. This cell is not a USA Environmental Protection Agency listed hazardous waste. It is fully encapsulated and should not be tampered with.