

Focus

Virtual Studio

General Description

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1 Introduction

Focus product line provides solutions for small and medium-sized television studios. It is a modern and increasingly popular technology of television production based on combining virtual scenery (computer-synthesized images) and live video, live actors and computer characters, etc. Conventional virtual studios are covered in literature well enough. Products created using the technologies are seen on television and cinema screens increasingly often. What bars the widespread proliferation of the technologies is the high price and complexity (rather novelty) of the technological process. When creating Focus family systems, we tried to meet the problems provided the quality and functionality intrinsic to many times more expensive systems are preserved. Moreover, the applied architecture allows you to use Focus systems not only as virtual studios proper but for the broadcast design during live broadcast: embedding animated virtual plasma screens, 3D characters, interactive business graphics, etc.

2 Purpose of Function and Functional Capabilities

The Focus system is oriented, first of regional, cable, Internet studios or television company divisions. As a virtual studio it allows you to organize production of a set of programs (news, weather forecast, entertainment programs) or other video production (video clips, etc.) using only one small studio without real scenery, light and television technique requirements being very small. At that, the visual quality of the production made can differ extremely little from the production of the world leading TV companies. An example of a product created using the Focus system is shown in Figure 1. An example of a Focus virtual studio when in use.



Figure 1. An example of a Focus virtual studio when in use.

Here are listed the main attributes of the Focus system:

- multiformat video input with time-base correction, which allows you to use nonsynchronous video sources;
- the ability of the video output synchronization (GenLock);
- unique chroma keying (chromakey, or rear projection) comparable with Ultimatte (qualitatively detailed thin and semitransparent objects: hair, smoke, glass, etc.);
- the number of input channels with independent keying and time-base correction can be easily increased;
- built-in sound delay for the output video and audio synchronization;
- calculating 3D scenes in real time using input dynamic video images as textures on any scene objects;
- unlimited number of animated virtual cameras;
- support of static or robotic source video cameras with switching between them in real time;
- a wide range of abilities in creating animated computer characters, interior elements, trick effects;
- controlling any objects and parameters automatically, by the script, or interactively;
- the ability of integration with video servers, titling equipment, and other external equipment, for example, to provide working by the common scenario.

The technology of the Focus virtual studio allows you to use various video sources, getting quite a quality result. This is achieved due to using decoders and time-base correction on each input channel, specially adapted unique algorithms of keying, filtration, and mixing. At that, due to modularity and expandability, the system can be easily developed to work with component, digital SDI or HD SDI signals.

Unlike the majority of other virtual studios, the actor image extracted after keying is further used as a material texture when generating 3D scenery in real time, which allows you to place the actor image in any place of a synthesized 3D scene and use animated virtual cameras. Hereby, instead of a complicated and expensive system of a real camera position sensors («tracking»), a computer emulation of motion and translocation is used. At that, it is possible to previously create arbitrarily complicated trajectories of such a motion, which is impossible in a real studio, or requires using extremely expensive crane equipment. Of course, the spectrum of virtual camera motions is restricted when using real static cameras, but it is quite enough for a very wide range of applications. For example, too a close location of a virtual camera to the actor will look as a digital zoom. Again, with the facilities of Focus it's impossible to show the image of the actor profile, that is, a walk around it without special tools (turn table, etc.). On the other hand, the system can be used in the usual overlay mode, when a full, unscaled video image of the actor is simply mixed with synthesized computer scenery (overlaid 1 texel per 1 pixel), the ability to imitate tracking in and tracking out being lost at that. Whereas the cost of the tracking systems is many times as expensive as the studio itself.

For a certain class of applications (for example, weather forecast) with a few static positions of cameras, the overlay mode is quite good as it allows you to show the actor video image with a maximal quality owing to absence of additional processing and filtration unavoidable when using video as a texture in synthesized 3D scenes.

In addition to the advantage of using the animation of virtual cameras, using video as textures gives great opportunities to create various special effects like morphing, multiplication of objects, regular reflections, using curved surfaces and many others. In particular, it's possible to create virtual TV panels with fanciful animation, arbitrarily distort the actor image, etc. As a source for such a video texture, not only a live source (video camera, VTR) can be used but also a video file, which can be played either directly from the hard disk of the virtual studio computer or from a separate file server. Provided, the session ensures a pure data transmission in the required amount. Working with video files by the NET can prove to be even more preferable, as it excludes the load influence on the system when the disk subsystem working. Of course, there are the overall system performance restrictions on the simultaneous playing of several such dynamic objects. The actual configurations allow you to operate simultaneously three or four full-size video textures depending on the general complexity of the synthesized scene. When minimizing the resolution, and consequently, the data streams, it's possible to correspondingly extend the number of video textures in the scene.

3 Technology Features

The process of television production using Focus can be represented in two stages: preparatory work and the shooting proper in real time. On the preparatory stage, the scenario of the created programme is studied. According to it, the corresponding set of 3D scenery is created, the necessary video and audio materials, design elements being fitted, the necessary animation of objects and virtual cameras being worked through.

Practically any action or changing parameters during the shooting can be performed either automatically, by the script, or interactively under the operator's control. Several operator's workstations for the interactive controlling various aspects of the shooting process can be used at that (e.g., several joysticks for controlling virtual actors). The system is built according to the principles of modularity and expandability and can be used independently, with an optiset corresponding to the process, as well as being integrated with the video equipment the user has.

Let's dwell on the stages of the technological process:

3.1 Preparation

3.1.1 Determining the Hardware Composition and Configuration

It's necessary to determine the composition of the television equipment used in the shooting process: the number of cameras (from 1 to 6), type, parameters, and location of cameras (it's possible to use up to three different video textures in a frame simultaneously), video equipment (videorecorders, mixer consoles, etc.), audio equipment, etc.

3.1.2 Creating a 3D Scene (Scenery)

The main tool for creating animated 3D Scenery is the widespread *3D Studio MAX* package. Using the package you can create the 3D scenery, animate movable objects, allocate video textures, virtual cameras, etc. (also possible using the *Maya* package). Of course, the real-time requirements put certain restrictions on the complexity of the created scenes and can demand the corresponding acquirements in optimization from the designers, which can be said of any virtual studios (the system performance is determined by the 3D accelerator used, CPU clock, RAM memory space, etc.). Even the heavy growth of the performance of computers and graphics accelerators recently and in the foreseeable future will not make it possible to remove such restrictions (including the most high-priced systems based on high-performance platforms). On the other hand, users not versed in 3D graphics can use a set of drafts or templates provided with the system or purchased from designers working with the virtual studio. The users of the templates can perform the necessary adaptations and modifications on them (e.g., change the colour, inscriptions on the objects, textures) via very simple means (any 2D graphics editor, etc.).

3.1.3 Arranging Video Materials

Previously digitized video materials (clips, video items, commercials, etc.) used when shooting are preliminarily arranged with the nonlinear editing system provided optionally. At that, logical projects or playlists (playback programs) without real rendering and copying data can be used to play back in real time. When integrating with external playback equipment (using an extra video input channel), the arrangement and playback are performed using other available means.

3.1.4 Preparing and Configuring the Interface Controlling 3D Scenery.

As a rule, a necessity to interactively control 3D scenery (switch virtual cameras, start animation, change virtual scenery, etc.) arises when shooting. To this effect, the user can previously create various sets of actions (hereinafter referred to as *Actions*) and interactive button panels corresponding to them. When shooting, the panels are to be used by the operator to control the virtual scenery: the operator starts the appropriate *Actions* pressing the corresponding buttons with the mouse, touchscreen or using the *Hotkeys* assigned to the buttons. The means allowing to maximally simplify the interaction of the operator with the system in real time are discussed in detail below in Section 5.

3.2 Shooting

3.2.1 On-Line Shooting (on Air)

Working in this mode is performed in real time and therefore requires thorough preparation of all the materials used, script, and activity of the operators and actors. To provide reliability, it's necessary to maximally use the means of the script automation and simplify the interface of the real-time operators as far as possible. In the interactive mode, the operator uses a previously configured interface of the virtual studio control, which is a set of button panels performing various control commands or *Actions* in the 3D scene. Starting *Actions* in the virtual studio can also be performed by pressing the *Hotkeys* or via GPI ports (controlling signals coming via *COM* or *USB* ports) from the external control devices, e.g., mixer consols. At that, standard production, e.g., the daily weather forecast will not require from the operators any kind of deep knowledge in using the system. A concise description of what action in the scene one or another button of the created interface performs will be sufficient.

3.2.2 Off-Line Shooting (Recording off Air)

This mode allows you to perform interactive shooting for picking the best takes and achieving the best results. Shooting can be performed by short clips, which facilitates working with the script and leaves room for improvised creativity.

4 System Components

4.1 Basic Configuration

The basic hardware is a specially fitted and configured computer of the IBM PC class with installed:

- audio and video input/output moduls with time-base correction and keying;
- a 3D graphics accelerator;
- special software.

In the basic configuration, Focus is a PC (system unit) with additional modules installed. The basic configuration is oriented to working with S-Video signals (three inputs) and/or Composite (up to six inputs), two independent video input channels from any video signal sources being provided. Video from the connected sources undergone time-base correction and keying can be switched in the Focus in real time. In a 3D scene, only one video texture (of two connected) from the external video channel or its several copies can be used. Playing video files as an additional video texture is supported provided the corresponding scene optimization by performance. The configuration includes audio delay and a nonsynchronized S-Video output. The ability of connecting external devices of interactive control via the local area network, from joysticks, GPI ports is supported.

4.2 Optional Add-ins

A set of optional add-ins includes:

- additional input channels of various formats (S-Video, YUV, SDI, HD SDI, up to eight input video sources);
- passive breakout box;
- active breakout box;
- 3D mice;
- device for transmitting signals via GPI;
- means of integration with a video server and titling system *Forward TA/Forward TT*.

Figure 2 and Figure 3 present diagrams of the Focus system typical configurations.

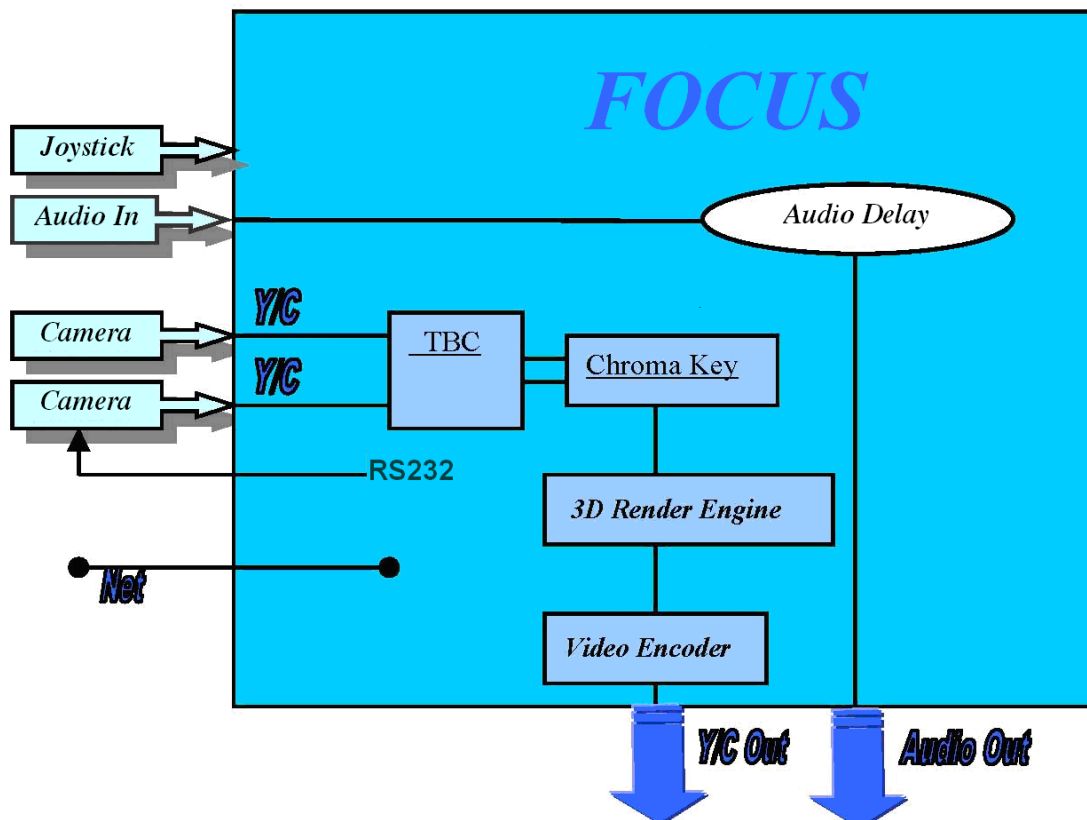


Figure 2. The basic configuration.

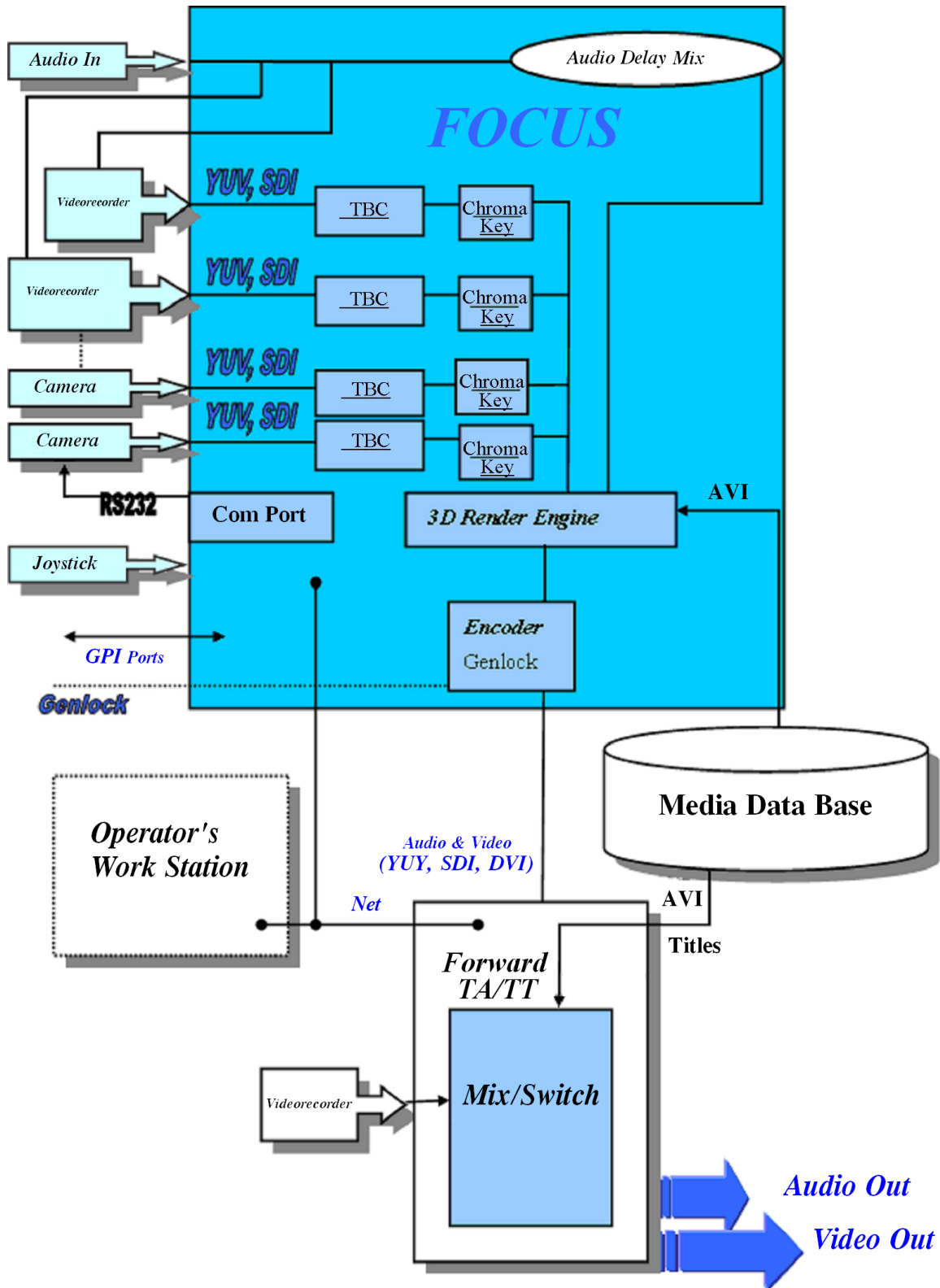


Figure 3. An extended configuration.

5 The Ideology of the User Interface

The main instrument for controlling the virtual scenery (3D scene) and cameras is the *HotActions* program, which is the main user's application of the Focus studio.

HotActions is used in two main modes:

1. **Edit Mode** – creating an interface for controlling the scene.
2. **LiveAction Mode** – shooting, demonstration.

It's supposed that those who work in the former mode are mainly designers and producers developing the virtual environment, animation, scenery, etc., and in the latter mode – technical operators controlling the scene.

5.1 Creating Interface for Controlling the Scenery (*Edit Mode*)

In this mode, *HotActions* is used to create and configure interface for controlling the virtual scene. The interface is to be used by the operator when shooting (in the **LiveAction Mode**). All the preparatory works before airtime are performed in this mode. The next Sections describe the process of creating the interface.

5.1.1 Creating *Actions* (Programming the Scene Behaviour)

Action is a logically closed action, which is one or several united commands. The result of executing the commands is a quick modification of the virtual scene. The commands are described in a special script language.

Particularly, the actions that refer to **Actions** are as follows:

- switching virtual cameras within the scene (changing their parameters);
- starting/stopping animation of different objects of the scene;
- quick loading individual textures and fonts as well as whole scenes;
- playing/stopping sound;
- changing some properties of the scene elements (e.g., the visibility of objects, their scale, location, color, etc.).

Some **Actions** can cause others (sequentially or simultaneously), that is, they are **scene sequences**.

Initializing Actions (Init-Action) are **Actions** of especial importance automatically executed when switching to **Live Mode**. They are created to bring a 3D scene to an initial (home) state, to load and initialize components necessary when working on air.

As a rule, the one who is engaged in creating **Actions** is the scene designer/ animator (as they are best acquainted with the scene structure) or the programme director.

A set of **Actions** is saved to the disk as documents of the **Actions Library** type (files with the ***.acl** extention).

5.1.2 Configuring Controllers

The *HotActions* application supports an unlimited number of connected controllers, particularly, joysticks or 3D-manipulators. Each of them can be configured to perform some actions (e.g., perform **Actions** by pressing/releasing buttons, rotate /relocate different objects of the scene according to the handle position, etc.). As a rule, the information of the controllers configuration is recorded in the text of the initializing **Actions** (see above).

5.1.3 Creating and Configuring *Hotsets*

Since each **Action** is an action (or a sequence of actions) to be performed, a certain button can be assigned to such an action. The action is to be executed by pressing the button. A panel consisting of such functional buttons is referred to as a **Hotbar**. The images on the buttons and the button names as well as the **Hotbar** form are fitted from different considerations of ergonomics. When desired, a **Hotkey** on the keyboard (**Keyboard shortcut**) can be assigned to each button.

Hotbars are placed in the working space of the **Hotset** window of a special document – **Hotset**. The information of the **Hotbar** configurations is recorded in the **Hotset** (files with the ***.hot** extention).

When loading a *Hotset*, the program automatically loads the necessary *Action* libraries, which are executed when pressing the buttons.

Hotset is independent from a specific content of one *Action* or another as it contains only a reference to it. Hereby, a *Hotset* can be composed directly by the operator controlling the scenery from considerations of usability when working on air.

5.1.4 Combining into a Project

The virtual scene files required for a specific broadcasting, the created libraries and *Hotsets* can be combined into a single project.

The references to the files used, the status of the documents (opened/closed/hidden), the location of the windows of the opened documents relative to the application main window are saved in the project document (*.vsp).

5.2 Live Broadcast Control Mode (*LiveAction Mode*)

The immediate interactive working with a 3D scene, that is, broadcasting (shooting, demonstration) is performed in *Live Mode*.

The main user of the mode is the virtual scene operator. Pressing the *Hotbar* buttons or using the *Hotkeys* the operator starts such and such *Actions* performing in this way interactive modification of 3D scenery. Simultaneous controlling the scene objects can be performed via different controllers: joystick, mouse, and other input devices.

When switching to this mode, the *HotActions* application changes its image to «no-extras-but-buttons». That helps the operator concentrate on their work.

It's also possible to start the execution of *Actions* from another computer connected via the net. Hereby, there may be several operators controlling the scene in extra difficult or important cases.

6 Technical Specification of the Virtual Studio (with Options)

Video Data Input Formats

PAL: 720x576, 25 fps, 4:2:2 or 4:2:2:4.

NTSC: 720x480, 29,97 fps, 4:2:2 or 4:2:2:4.

HDTV: 1280x720p, 50/59.94 fps, 1920x1080i, 25/29.97 fps.

Video Data Output Formats

PAL: 720x576, 25 fps, 4:2:2 or 4:2:2:4.

NTSC: 720x480, 29,97 fps, 4:2:2 or 4:2:2:4.

HDTV: 1280x720p, 50/59.94 fps, 1920x1080i, 25/29.97 fps.

Internal Processing Video Data

YUV 4:2:2 or YUV α 4:2:2:4, 8 bits per component.

Video Inputs

Up to **12 Composite (RCA)** (1.0Vp-p, 75 Ohm).

Up to **6 S-Video (4-pin mini-DIN or BNC)** (Y:1.0 Vp-p, 75 Ohm; C: 0.286 or 0.3 Vp-p at burst level, 75 Ohm).

Up to **3 Component YUV (BNC)** (Y:1.0 Vp-p, 75 Ohm; U/V: 0.7 Vp-p, 75 Ohm)
or **RGB (BNC)** (R/G/B:1.0 Vp-p, 75 Ohm).

Up to **3 SDI (BNC)** (SMPTE 259M – 270Mbps).

Up to **4 HD SDI (BNC)** (SMPTE – 292M).

Video Outputs

Composite (RCA) (1.0Vp-p, 75 Ohm).

S-Video (4-pin mini-DIN or BNC) (Y:1.0 Vp-p, 75 Ohm; C: 0.286 or 0.3 Vp-p at burst level, 75 Ohm).

Component YUV (BNC) (Y:1.0 Vp-p, 75 Ohm; U/V: 0.7 Vp-p, 75 Ohm)
or **RGB (BNC)** (R/G/B:1.0 Vp-p, 75 Ohm).

SDI (BNC) (SMPTE 259M – 270Mbps).

HD SDI (BNC) (SMPTE – 292M).

Audio

6 input mono channels (3 stereo channels) 16 bits, up to 48 kHz.

6 output mono channels (3 stereo channels) 16 bits, up to 48 kHz.

Configurable audio delay for each input channel.

Mixing of any input channel to any output channel with controlled volume level.

Synchronization of audio with the current video signal.

Balanced XLR connectors (optionally).

Time-Base Correction

From 2 to 8 TBC channels.

Color key

Original tabular with color correction and clipping.

3D Graphics

Real-time at approximately 500 000 visible polygons per frame.

Video Processing Delay

Fixed, from 3 to 5 frames depending on the mode of operation.

Synchronization

Optional Genlock module.

7 Annotations on the Current Solution

The complexity of the 3D scenes used in the system is restricted mostly by the performance of the hardware/software platform (Windows-based), which is developing right along. The manufacturer reserves the right to change the internal configuration of the system at any time and offers free and paid updates to all the users of the system. Users' own modifications are extremely objectionable and may result in a denial of warranty and maintenance service .