White Paper

The FLEXIVISION III concept

What's inside?

- FLEXIVISION III's modular system architecture
- Various video windowing features
- General design features

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FLEXIVISION III, Barco's modular video-processing platform, brings advanced capabilities to the military surveillance and reconnaissance market. FLEXIVISION III is an integrated solution for video and graphics mixing, image processing and network-centric imaging. The article discusses the modular design and various functionalities of the subsystem.

Table of contents

1 THE FLEXIVISION III FAMILY OF PRODUCTS 4
1.1 FLEXIVISION III carrier module 4
1.2 Universal Frame Grabber module 6
1.3 JPEG 2000 module 7
1.4 Programmable video processor module 8
2 THE FLEXIVISION III VIDEO WINDOWING FEATURES 9
2.1 Video layering 9
2.2 Video and graphics mixing 9
2.3 Window positioning 9
2.4 Window magnification 10
2.5 Panning 10
2.6 Image freeze frame 10
2.7 Video capture 10
3 THE FLEXIVISION III GENERAL DESIGN FEATURES 11
3.1 Switch fabric selection for FLEXIVISION III 11
3.2 Video latency 12
3.3 Output video formats 12
4 SAMPLE APPLICATIONS OF THE FLEXIVISION III SYSTEM: 13
4.1 Example: Six video windows with standard Video and Graphics Mixing 13
4.2 Example: Programmable video processing functions such as video fusion performed on two inputs. 13
4.3 Example: Recording of entire screen to hard drive. Image consisting of processed video source plus master graphics 13
4.4 Example: Networked video with two input sensor videos 14

1 THE FLEXIVISION III FAMILY OF PRODUCTS

FLEXIVISION III is a state-of-the-art video-processing platform that brings advanced capabilities to the military surveillance and reconnaissance market. FLEXIVISION III makes use of a PowerPC tightly coupled with a RapidIO switch fabric and an onboard dedicated Gigabit network interface. An array of video processing modules allows a wide variety of functions to be easily implemented within the product platform. A dedicated web-server interface creates an OS-independent environment for a windowing configuration set-up.

FLEXIVISION III is an integrated solution for video and graphics mixing, image processing, and network-centric imaging. It is made up of a set of modular components that can be combined in a variety of ways to perform functions like video mixing of local analog or digital video sources, video compression and streaming, and real-time image processing functions, such as noise reduction, image stabilization, video warping, and sensor fusion.

The signal flow for FLEXIVISION III consists of routing a master graphics input and a set of sensor inputs into the system. The sensor inputs are digitized, processed, and mixed with the master input to create an integrated output to the display device. The integrated output signal matches the format of the master input signal. FLEXIVISION III also supports masterless operation where desired output timing is specified by the user and created by the hardware.

1.1 FLEXIVISION III carrier module

The FLEXIVISION III carrier board is based on a RapidIO switch fabric architecture that is tightly coupled with a local on-board PowerPC. The hardware is designed to support optional mezzanine modules that implement specific functions. Each FLEXIVISION III carrier board provides a dedicated Gigabit network interface. Multiple FLEXIVISION III boards can be jointly configured through the switch fabric to create expanded video processing functionality. Figure 1.0 illustrates the FLEXIVISION III carrier board architecture. The control block contains the on-board PowerPC and runs an embedded Linux operating system.

The FLEXIVISION III carrier board supports twenty analog video input signals that can be configured in a variety of ways. For example, these input lines can be configured to support three RGB input sources and four composite RS-170 input sources. Any of these input sources are available to any of the mezzanine modules for processing. Standard software control is used to select and swap between any of the input videos.

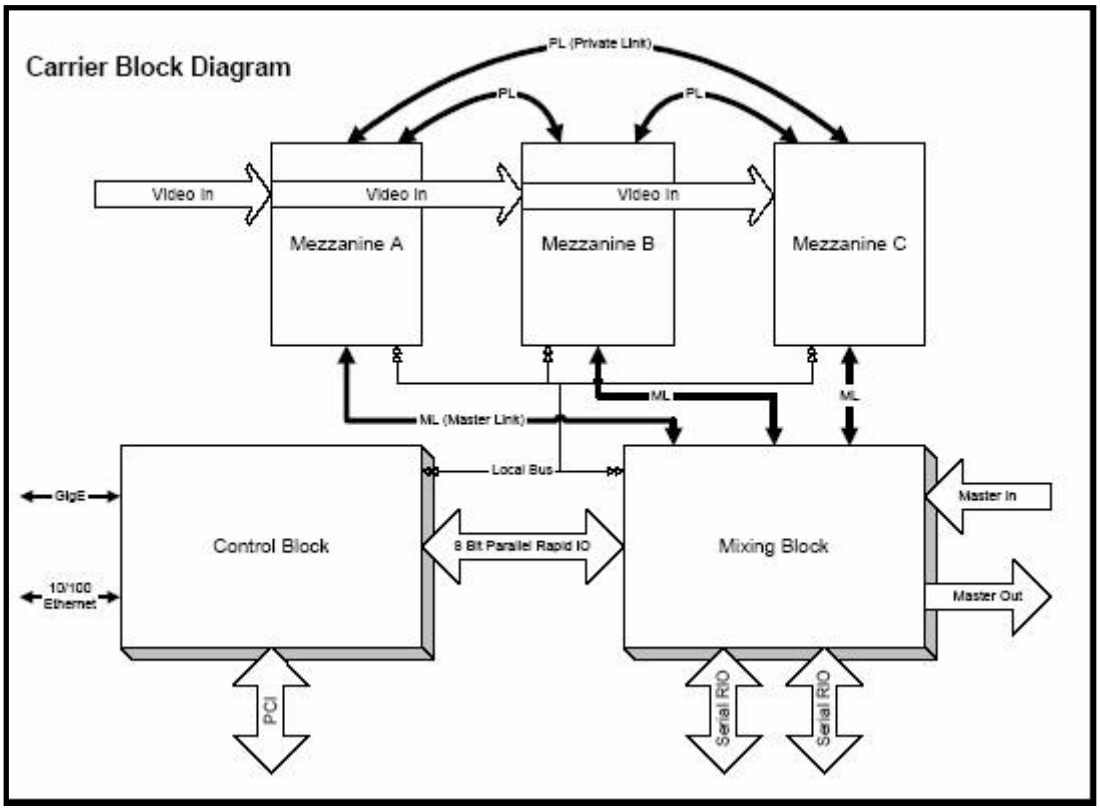


Figure 1.0: FLEXIVISION III Carrier Block Diagram

The FLEXIVISION III carrier board is currently available in a standard PCI form factor as shown in Figure 1.1, and will be reconfigured into 6U cPCI, VME and conduction-cooled form factors.

Figure 1.1: FLEXIVISION III – PCI Carrier

1.2 Universal Frame Grabber module

The FLEXIVISION III Universal Frame Grabber (UFG) module, shown in Figure 1.2, is a dual channel analog video frame grabber that is capable of supporting virtually any standard analog video format. Each UFG drives two independent video processing channels with a full suite of standard video mixing functions. Up to three UFG modules can be configured on the FLEXIVISION III carrier board to enable a total of six simultaneous video channels to be displayed by the video windowing subsystem. As noted in the previous section, all analog video input signals are available to any of the UFG processing channels.

Supported functionality:

- Video scaling with frame rate conversion
- Input Frame Buffer and Output Frame Buffer memory control
- Color space conversion
- Cropping, zooming, panning, and positioning per window
- Brightness, contrast, and gamma correction control
- Auto-detect logic for zero user set-up

Supported signal formats:

- NTSC/PAL/SECAM composite or S-Video
- STANAG 3350 monochrome
- RS-170
- RS-343 up to 1280x1024 @ 75 Hz
- HDTV analog up to 1080i with bi- or tri-level sync
- Single link DVI

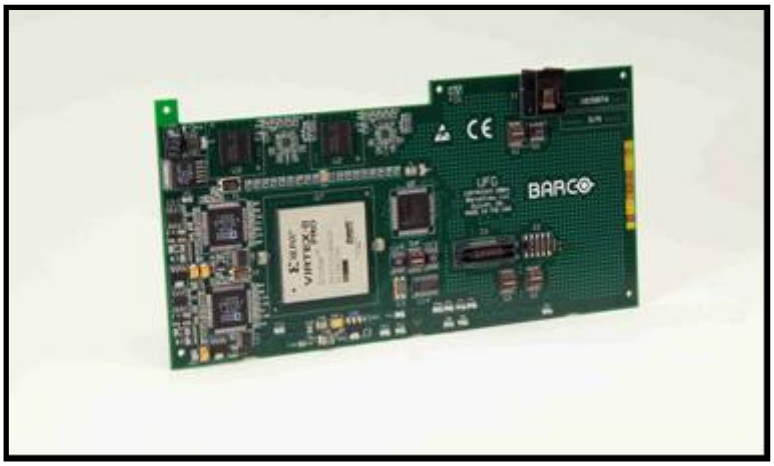


Figure 1.2: FLEXIVISION III Universal Frame Grabber Module

1.3 JPEG 2000 module

The FLEXIVISION III JPEG 2000 (J2K) module, shown in Figure 1.3, is a JPEG2000 processor-based Codec module. With this wavelet domain-based compression technique, it possible to select the level of compression (from lossless to lossy) based on system requirements, such as high-resolution input and low latency distribution. The module is capable of encoding or decoding four low-resolution (NTSC/PAL/SECAM) images simultaneously in real-time. Alternatively, it can be used to encode or decode one high-resolution signal up to 1920x1200. Encoded images can be streamed out over the FLEXIVISION III carrier board's Gigabit Ethernet to other J2K modules configured as decoders.

Next to this, encoded images can be recorded to dedicated hard drives for archiving through the Serial ATA disk interface provided by the J2K module. Decoded images received over Gigabit Ethernet are available to the mixer for insertion into the master graphics output and displayed as windows. The J2K is designed for minimal delay when encoding and decoding to provide low latency network video distribution.

Capabilities:

- JPEG 2000 encoder/decoder
- Low latency video streaming
- Wavelet based lossless compression capability
- Video recording through on-board disk interface

Figure 1.3: FLEXIVISION III JPEG 2000 Module

1.4 Programmable video processor module

The FLEXIVISION III Programmable Video Processor (PVP) module accepts digital format video from any of the other modules and processes it with its on-board FPGA. The PVP is a derivative of the UFG without the need for analog front-end circuitry. The PVP provides the core of the FLEXIVISION III image processing capabilities, and provides a growth path for the evolution of vision enhancement capabilities in standard COTS product.

As mentioned above, the initial release of FLEXIVISION III contains an FPGA-based processing module capable of implementing a variety of vision processing functions. A DSP-based Programmable Video Processor is also defined in the FLEXIVISION III product platform.

A wide variety of image processing and image enhancement functions are implemented via the PVP.

Supported functions:

- Video fusion
- Video warping
- Image stabilization
- Super resolution

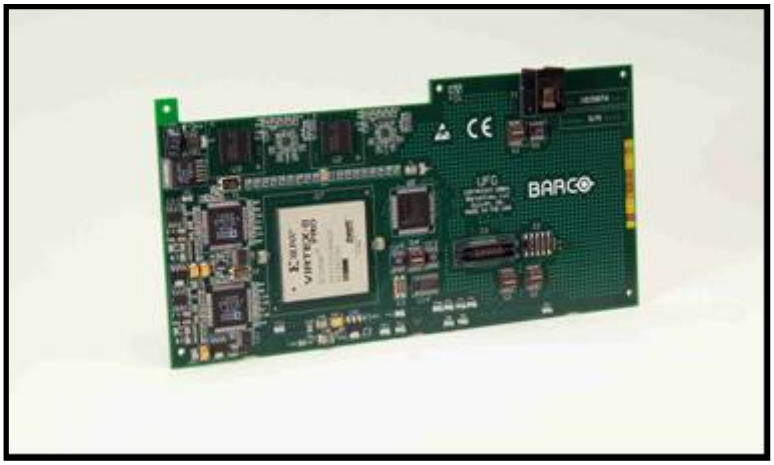


Figure 1.4: FLEXIVISION III Programmable Video Processor

2 THE FLEXIVISION III VIDEO WINDOWING FEATURES

2.1 Video layering

The FLEXIVISION III video windowing subsystem implements three virtual visualization layers based on chroma-keying techniques. Graphics can be rendered in a lower virtual layer in non-chroma key colors. Chroma-key colors (to be substituted with live sensor input streams) can be rendered where video windows are required to create a middle virtual layer. Finally, non-chroma key colors can be rendered on top of the video windows. This allows various text or graphics to be annotated on top of the video windows in a third virtual layer. This chroma-keying scheme is widely used on Barco video products for both analog and digital implementations.

2.2 Video and graphics mixing

The FLEXIVISION III video windowing subsystem provides a flexible set of operational features that make video windows behave much the same as typical graphics windows. Video windows can be arbitrarily stacked and overlaid against one another just as typical graphics windows. Obscured or clipped portions of the video are opaquely hidden, while the exposed areas of the video windows show the relevant portion of the signal. As video windows are stacked using a window manager, videos on top obscure videos that are lower in the stacking order.

As mentioned in the discussion of video layering, the FLEXIVISION III system supports chroma-keying as a method for selecting either the master graphics stream or a specified video stream on a pixel-by-pixel basis. The FLEXIVISION III system also supports alpha-blending between any of the video streams. The mixing block of the FLEXIVISION III carrier board has entries to all video streams, and ultimately chooses the color of each pixel to be displayed. The alpha-blending function is performed in the mixing block FPGA when enabled.

2.3 Window positioning

Each video window supported by the FLEXIVISION III video windowing subsystem can be independently positioned on the display surface. These video windows can be moved partially off-screen in any direction (up, down, left, or right). When positioned partially off-screen the relevant portion of the video window continues to be displayed. Each video window can also be independently scaled to an arbitrary size and shape rectangle.

2.4 Window magnification

The FLEXIVISION III video windowing subsystem utilizes the UFG mezzanine for video scaling and magnification. The image can be reduced in size on a continuous scale down to 1/32 of the original input image. The image can be zoomed (or magnified) in size up to 32x of the original image, subject to the limits of the display surface resolution.

2.5 Panning

When an image is zoomed (or magnified) and the displayed video window size remains constant, a condition is created where portions of the original image are not visible within the window. In this case, the FLEXIVISION III system provides a function for panning through the zoomed image. The zooming functions allow any arbitrary portion of the original image to be displayed within the video window subject to the 32x zoom and scale capabilities of the UFG.

2.6 Image freeze frame

The FLEXIVISION III video windowing subsystem allows for any displayed video source to be frozen on the screen without update. When the image freeze is disabled, the video stream is restored in real time. Any video information that transpires during the freeze operation is not visible or recoverable.

2.7 Video capture

The FLEXIVISION III subsystem provides a video capture feature on two levels. The first level of video capture handles any individual data stream. The video image is briefly frozen on the output frame buffer of the specified UFG and transferred to a storage device. Once the data is captured, the live video stream resumes. A second level of video capture takes care of full screen image, including all videos that are currently displayed. The full screen image is shadowed in local memory near the mixing block of the FLEXIVISION III carrier board, and is available for screen dump any time. The full screen image is transferred to a storage device without interruption or pausing of the operator's display. All video captures are performed in the Portable Pixmap format (".ppm"), from the FLEXIVISION III system and then further compressed to JPEG format.

3 THE FLEXIVISION III GENERAL DESIGN FEATURES

3.1 Switch fabric selection for FLEXIVISION III

The FLEXIVISION III system architecture has been carefully considered to provide a useable and expandable video windowing subsystem for many years. One of the key features of FLEXIVISION III is the use of switch fabric technology to support the high-speed data interconnections required of video processing subsystems. There are many switch fabric technologies in evolution today, and the choice of an appropriate fabric is driven by a combination of the requirements of the system, and the availability of the technology. While the most advanced switch fabric technologies are arguably Infiniband and StarFabric, those technologies are not as well suited for the chip-to-chip and board-to-board interconnections required by an embedded video windowing subsystem. Consider the following diagram that illustrates the relatively maturity of various switch fabrics versus their specific applicability:

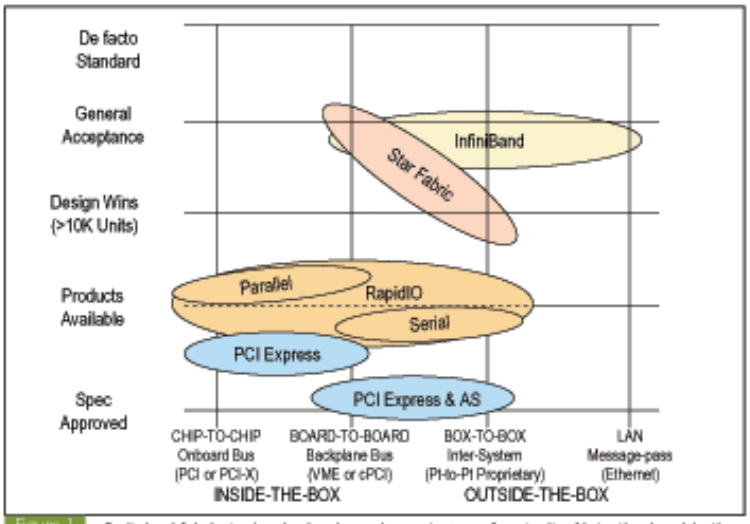


Figure 1 Switched-fabric technologies in various stages of maturity. Note the level in the I/O hierarchy that each one targets.

Based on its maturity and availability, RapidIO was chosen for the FLEXIVISION III video windowing system. It is anticipated that translations between various switch fabric architectures will also evolve to standards in the market. For example, it will be possible in the future to utilize technologies such as Infiniband for box-to-box communications, and translate to technologies such as RapidIO inside processors, such as the proposed DP, for a single continuous data stream.

3.2 Video latency

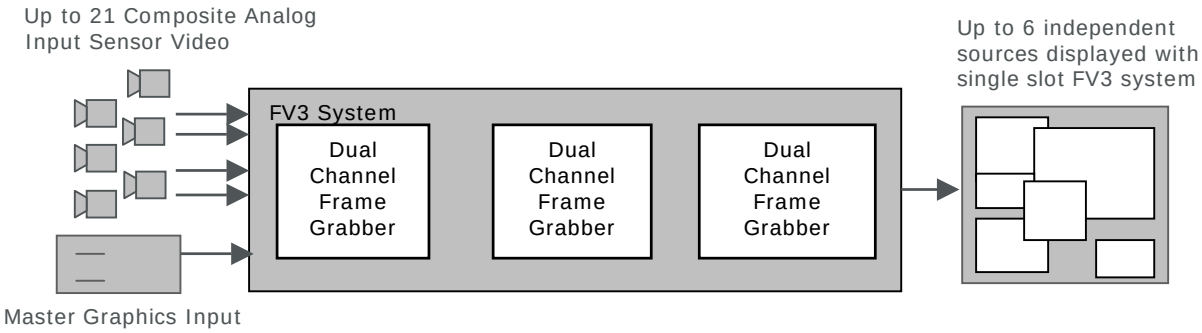
Video latency from the time of analog input to the FLEXIVISION III to the display device is dependent on the functions applied to the video stream. In typical video windowing subsystems there is a need for both frame rate conversion of the input video, and scaling of the input video. The frame rate conversion synchronizes the update of the video stream to match that of the integrated output to the display surface. This process prevents visual tearing of the video stream when viewed by the operator. The scaling function allows video frames to be appropriately buffered then presented on the screen with arbitrary resizing factors for scaling and zooming. There are a number of factors that contribute to the latencies in such implementations and maximum latency values typically range from approximately 50ms – 100ms. The FLEXIVISION III implementation is expected to yield approximately 50ms latency for locally embedded solutions and approximately 80ms for networked solutions.

3.3 Output video formats

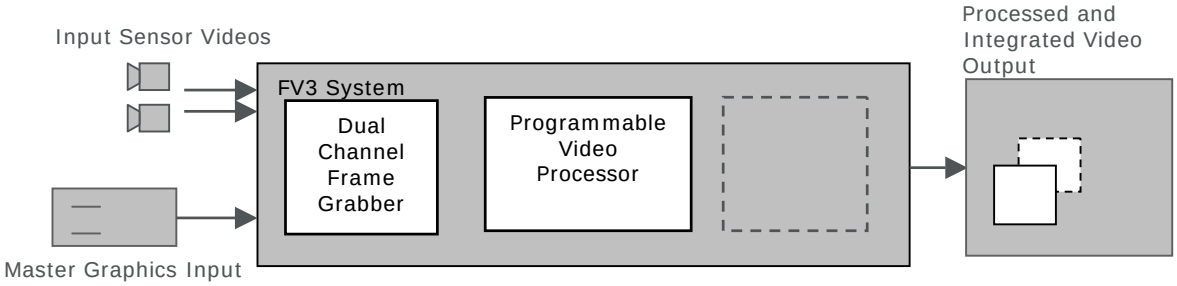
The output from the FLEXIVISION III board set supports both analog RGB and DVI output formats up to 1900x1200 resolutions.

4 SAMPLE APPLICATIONS OF THE FLEXIVISION III SYSTEM:

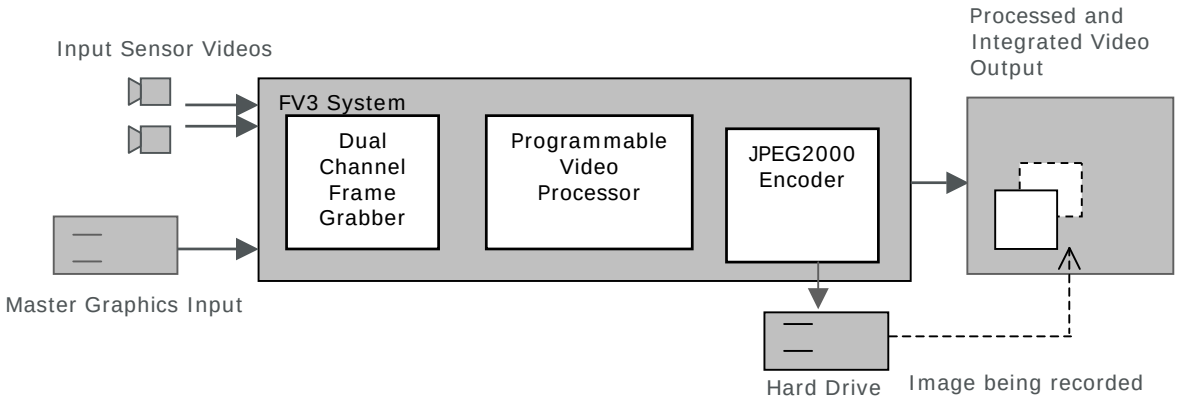
4.1 Example: Six video windows with standard Video and Graphics Mixing



4.2 Example: Programmable video processing functions such as video fusion performed on two inputs.



4.3 Example: Recording of entire screen to hard drive. Image consisting of processed video source plus master graphics



4.4 Example: Networked video with two input sensor videos