

12G/3G/HD/SD/Analog/HDMI/DVI/RGBHV Mixed High Resolution Multi Viewer  
(Up to 68 Inputs, 8-Monitor Outputs)

**FOR.A**<sup>®</sup>

**MV-4000 series**

12G/3G/HD/SD/ANALOG/HDMI/DVI/RGBHV  
MIXED HIGH RESOLUTION MULTI VIEWER  
**MV-4000 SERIES**



# MV-4000 SERIES

Up to 68 inputs, with 8-monitor/114-window outputs. Simplifies 4K workflows by accepting mixed input, including 12G-SDI. Layouts for each output can be freely customized.

## Available Units

### MV-4200 series



Provides up to 68 inputs and 8-monitor/114-window outputs in a 2U enclosure. Add up to 3 optional cards.

#### MV-4200

Displays up to 114 windows. Includes 4 outputs each for 3G-SDI and HDMI. Add up to 10 inputs for 12G-SDI.\*1

#### MV-4210

Displays up to 114 windows. Includes 8 outputs for 3G-SDI. Add up to 10 inputs for 12G-SDI.\*1

#### MV-4220

Displays up to 110 windows. Choose from 2 inputs + 2 outputs for 12G-SDI or 8 inputs + 4 outputs for 3G/HD-SDI + 4 outputs for HDMI. Add up to 12 inputs for 12G-SDI.\*1

### MV-4300 series



Provides up to 68 inputs and 8-monitor outputs in a 3U enclosure. Add up to 3 optional input cards and 1 interface expansion card. Also accepts a hot-swappable power supply.\*1

#### MV-4300

Displays up to 114 windows. Includes 4 outputs each for 3G-SDI and HDMI. Add up to 15 inputs for 12G-SDI.\*1

#### MV-4310

Displays up to 114 windows. Includes 8 outputs for 3G-SDI. Add up to 15 inputs for 12G-SDI.\*1

#### MV-4320

Displays up to 110 windows. Choose from 2 inputs + 2 outputs for 12G-SDI or 8 inputs + 4 outputs for 3G/HD-SDI + 4 outputs for HDMI. Add up to 17 inputs for 12G-SDI.\*1

\*1 Optional

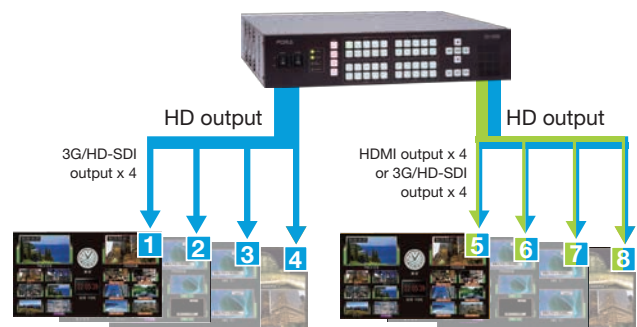
## Up to 68 input channels with optional cards\*2

- Combine optional input cards, MV-4200SDI (3G/HD/SD-SDI, Composite x 20), MV-4200PCI (DVI-I/HDMI/RGBHV x 8), MV-4220SDI (12G x 5 or 3G/HD/SD-SDI x 20), or the optional MV-4200IF interface card (GPIO, serial control, input of analog audio, AES audio, genlock) as needed.

\*2 Up to three optional MV-4200SDI or MV-4220SDI cards

## Customized layouts in HD on up to 8 monitors

- Up to 114 windows over 8 output displays
- Up to 8 clocks per 8 output displays
- Up to 8 logos and 1 background per 8 output displays



## 4K I/O\*3 via 12G-SDI or 3G-SDI

- Layout Manager enables easy layout of 4K video in a seamless display.



\*3 12G-SDI output requires MV-4220 or MV-4320.

## HDMI 2.0 Level B output

- 4K (UHD) output (3840 x 2160, YUV 4:2:0) over a single HDMI cable



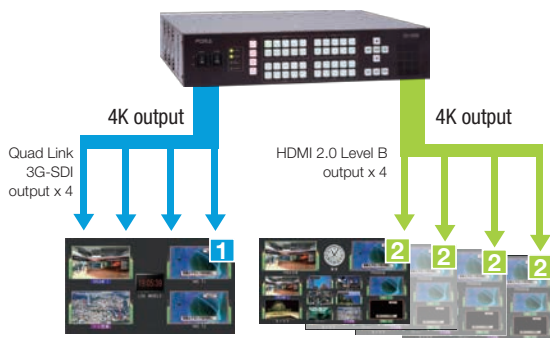
## Crosspoint control for 4K playback

- Four input signals assigned to crosspoints 1 to 4 can be controlled together.

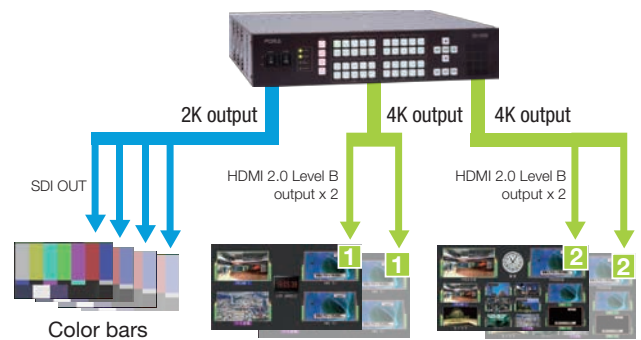


## With HDMI 2.0 Level B, choose from two layouts

- 4K output (1 channel) + 4K output x 4 (1 channel)

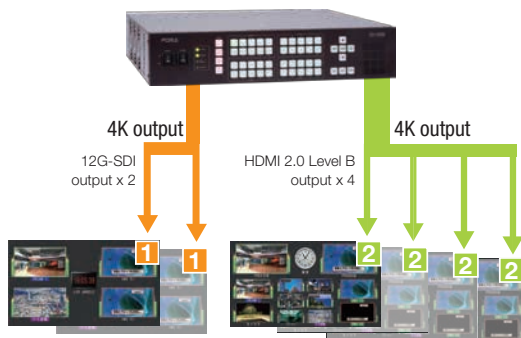


- HD color bar output x 4 + 4K output x 4 (2 channels, 2 outputs per channel)

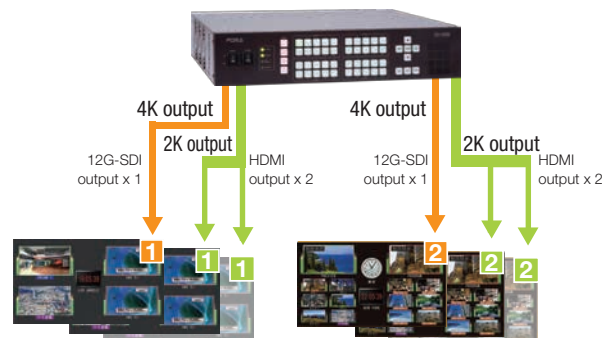


## Layouts for 12G-SDI output\*3

- 4K output x 2 (1 channel) + 4K output x 4 (1 channel)

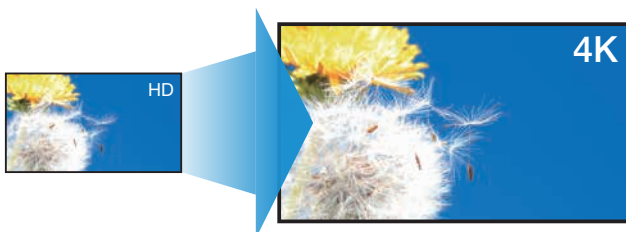


- 4K output x 1/downconverted 4K → 2K HDMI output x 2 + 4K output x 1/downconverted 4K → 2K HDMI output x 2



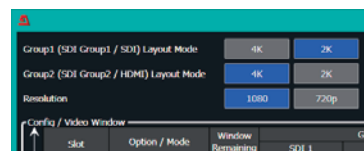
\*3 12G-SDI output requires MV-4220 or MV-4320.

## HD to 4K up-resizing

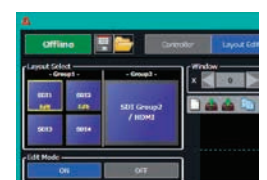


## 2K or 4K SDI/HDMI output in customizable layouts

- Mixed 2K/4K output also supported.



2K/4K output setting screen



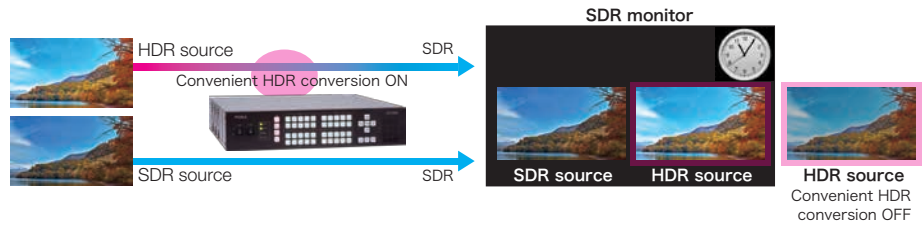
SDI/HDMI layout setting screen

## HDR/SDR Conversion

In mixed HDR (HLG format\*4) and SDR environments, the convenient HDR/SDR conversion features enable easy monitoring of video near the original luminance and saturation, regardless of the type of monitor used.

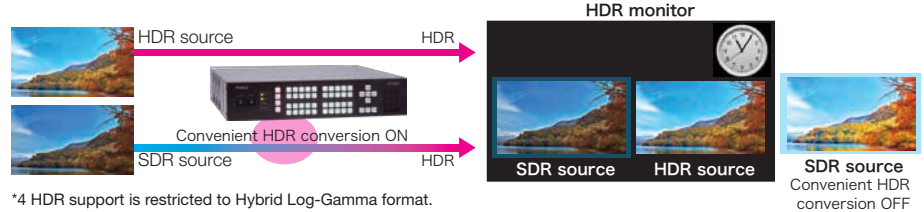
### Conversion from HDR to SDR

View HDR material on SDR monitors at near-original brightness and saturation\*5, instead of the dull, flat display that SDR monitors normally produce.



### Conversion from SDR to HDR

View SDR material on HDR monitors at near-original brightness and saturation\*5, without any excessive brightness or saturation.



\*4 HDR support is restricted to Hybrid Log-Gamma format.

\*5 Basic conversion for convenient viewing. Brightness and saturation differ from the original material.

### Convenient conversion of multi viewer graphics

SDR-based graphics created in multi viewer such as titles, tallies, clocks, and level meters are converted for display on HDR monitors. This prevents overemphasized multi viewer graphics on HDR material.

## Layout Manager

Windows®-based screen layout creation and management software. Customize layouts using the software to adjust image size, position, title display and other settings. Store up to 68 layout patterns on the multi viewer. Saved layouts can be recalled directly from the front panel control.

### Preview video and customize settings

Enter the viewer's IP address in a browser to access the control screen

Check viewer information and video output

Can also be viewed on a tablet, thanks to responsive design

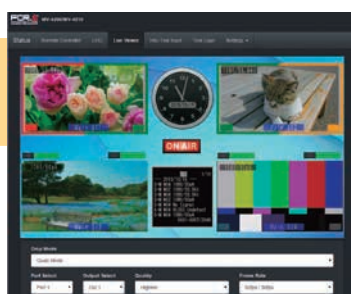
► Understand crosspoints at a glance



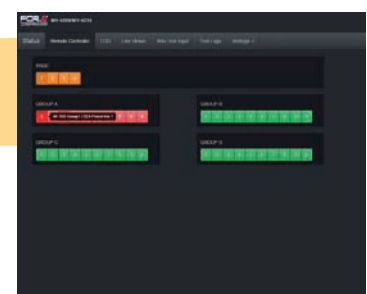
► Customizable layout



► Easy access and display in browsers



► Remote control settings



## Video Streaming

In addition to computer-based layout management, video can be streamed from the multi viewer over Ethernet. Streamed video can be viewed locally via Ethernet using a computer display as a secondary monitor. Remote monitoring is also supported.

## Record Streamed Video

Take streaming a step further by capturing the video. Frames before and after errors or specified triggers are captured and can be saved to a Windows® computer as still-image sequence files.

## Versatile Mixed-Source Environment

Supports mixed signals including: 12G-SDI, 3G-SDI (Level-A/B), HD-SDI, SD-SDI, Composite, HDMI, DVI, or RGBHV sources. Asynchronous input is also supported. The multi viewer accepts an array of formats and frame rates including NTSC, PAL, 1080/59.94i, 1080/50i, and 30/29.97/25/24/23.98p or PsF. (No frame rate conversion)

## HD Output of Source Signals

Up to 8 channels of monitoring output, with 4 HDMI and 4 SDI interfaces\*4

\*4 8 channels of SDI monitoring output for the MV-4210 and MV-4310

## Audio Level

Monitor up to 16 channels of audio levels in each 12G/3G/HD/SD-SDI or HDMI signal. Use Layout Manager to customize display positions, number of channels, and display groups.

## Audio Monitoring Output

Audio from any channel can be monitored via 12G/3G/HD-SDI, HDMI, or analog audio output.

## Prominent Error Display

Errors can be displayed using flashing borders, error icon, or error messages identifying the relevant frame:

### Error triggers include

Video loss, frozen frames, incorrect luminance/black levels, CRC errors, HDCP errors, audio loss, silence, excessive audio levels, 2SI input errors, and closed captioning loss

## Frozen Frame Detection

To enable the multi viewer to respond to changes in chroma, depending on the field, due to data compression or expansion, Y/C or Y alone can be detected.

## Tally, Title, and Timecode

- Tally: Frame tally and marker tally display
- Titles: Identify each source channel with a title. Supports display of logos, alphanumeric characters, symbols, and Chinese characters (up to 16 letters), which can be displayed within or outside the picture. The multi viewer can convert and save the characters typed on a computer as a logo in bitmap format for later use on the viewer screen.
- Timecode: Ancillary Timecode in 12G/3G/HD/SD-SDI signals can be displayed.

## Time of Day, Timer, and Information Display

The multi viewers support clock time synchronization with SNTP servers. Up to 8 clocks can be displayed in analog or digital format. Date display is also available. The Date display feature can be used as a count up/down timer, remaining time counter, schedule timer, or for information display.

## Information Display

Information for display includes error logs from each window, user-entered text, and multi viewer information.

## Logo/Background

Up to 8 logos can be added. Backgrounds can be added to each of the 8 outputs (2 outputs in 4K operation.)

## Input Lock

Input lock for each of the 8 standard inputs enables genlock without using reference signals.

## Can display time based on a 30-hour clock

Time display can begin at 6 a.m., with midnight to 5 a.m. as hours 24–29 in a 30-hour period. Settings between 24-hour and 30-hour clocks are made in 1-hour increments.

## Schedule Timer

As a trigger to display the remaining time, up to 24 times can be scheduled per day, on each weekday. Import and export schedule timer files as needed.

## Cropping

Specify areas to crop from any side of a window in pixels or by percent. Background image is shown outside of cropped areas. Aspect ratio is also maintained after partial cropping (of one side, for example). Sides can be extended after cropping to enlarge the display.

## Options

With the MV-4000 series, you can add only the input formats you need, in just the amount needed. There are up to four expansion slots so that other inputs can be installed, including HDMI, DVI-I and RGB in addition to 12G/3G/HD/SD-SDI and analog composite.

### MV-4200SDI

3G/HD/SD-SDI or analog composite input expansion card

- Expanded 3G/HD/SD-SDI/composite input: 20 channels
- Up to 34 windows supported



### MV-4220SDI

12G/3G/HD/SD-SDI input expansion card

- Expanded 12G-SDI input (5 channels) or 3G/HD/SD-SDI input (20 channels)
- Up to 20 windows supported
- Add up to 2 cards to the MV-4200 series or 3 to the MV-4300 series



### MV-4200PCI

PC (DVI-I/HDMI/RGBHV) input expansion card

- Expanded DVI-I/HDMI/RGBHV (HDCP-compliant) input: 8 channels
- Up to 11 windows supported



### MV-4200IF

Interface expansion card

- Several kinds of expanded input: AES and analog audio (8 channels each), serial control, GPIO (144 pins, for input and output), and reference input



MV-4200PCI Formats			
HDMI/DVI-I		RGBHV	
SMPTE	VESA (DMT)	SMPTE	VESA (DMT)
1920 x 1080/59.94p	640 x 480p	1920 x 1080/59.94p	640 x 480p
1920 x 1080/50p	800 x 600p	1920 x 1080/50p	800 x 600p
1920 x 1080/59.94i	1024 x 768p	1920 x 1080/59.94i	1024 x 768p
1920 x 1080/50i	1280 x 1024p	1920 x 1080/50i	1280 x 1024p
1280 x 720/59.94p	1360 x 768p	1280 x 720/59.94p	1360 x 768p
1280 x 720/50p	1366 x 768p	1280 x 720/50p	1366 x 768p
720 x 480/59.94i *5	1440 x 900p	-	1440 x 900p
720 x 576/50i *5	1680 x 1050p	-	1680 x 1050p
-	1600 x 1200p	-	1600 x 1200p
-	1920 x 1200p	-	1920 x 1200p

\*5 Only HDMI supported.

### MV-4200SNMP

SNMP-compatible software

- SNMP-based control and monitoring

### MV-4200PS/MV-4300PS

Redundant power supply unit

- Redundant power supply for added operational protection

## AUX REMOTE CONTROL PANEL

- Four types of AUX remote control panels available
- Up to 8 control panels can be connected simultaneously



HVS-AUX16A  
(16 buttons)



HVS-AUX16B  
(16 buttons, tabletop model)



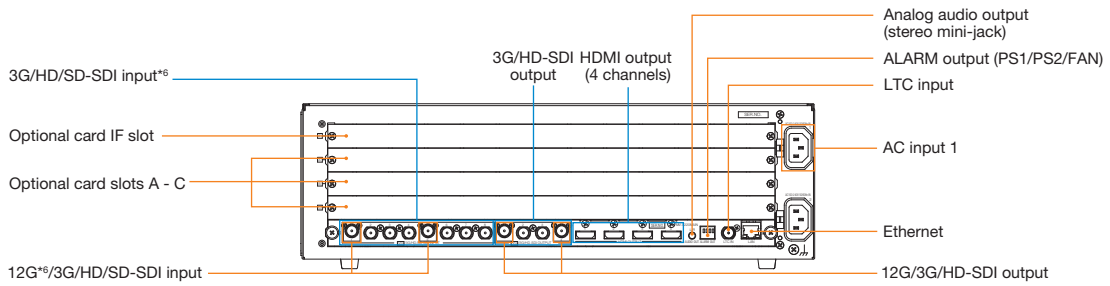
HVS-AUX32A  
(32 buttons)



HVS-AUX64A  
(64 buttons)

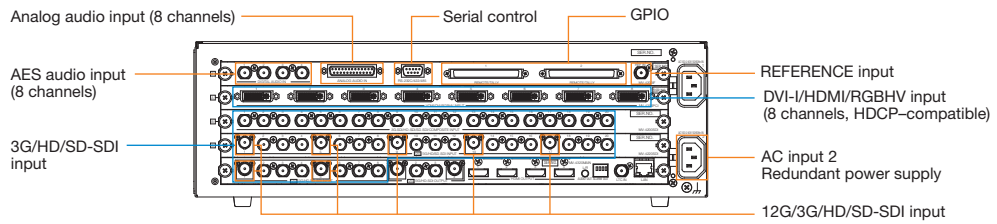
## A variety of optional cards to expand your network connectivity

### MV-4320



### Example of expansion

With MV-4200IF, MV-4200PCI, MV-4200SDI, MV-4220SDI and optional cards MV-4300PS (from top to bottom) mounted

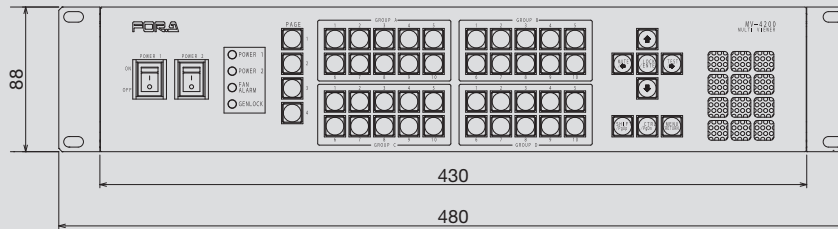


\*6 Provided with Input Lock function.

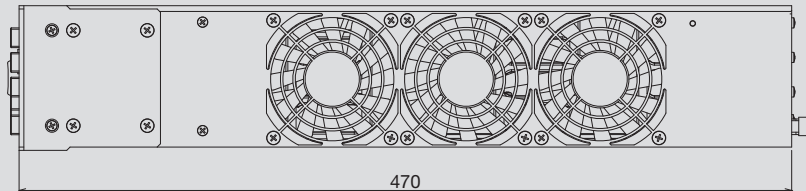
## External view

Unit: mm

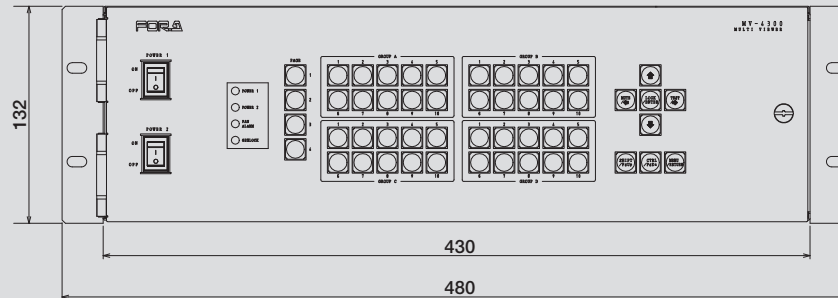
MV-4200/4210 /4220 front



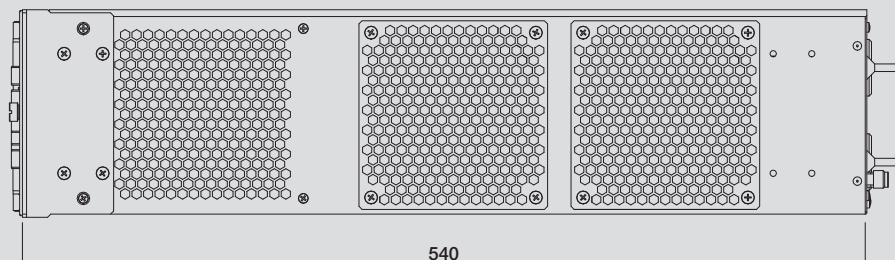
MV-4200/4210 /4220 side



MV-4300/4310 /4320 front

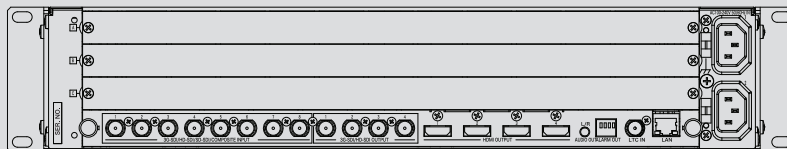


MV-4300/4310 /4320 side

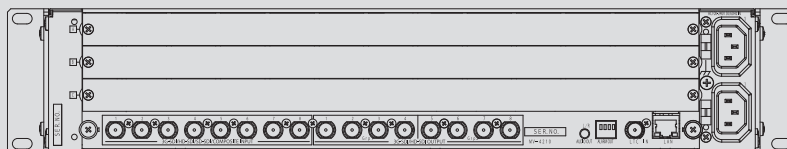


## Rear view

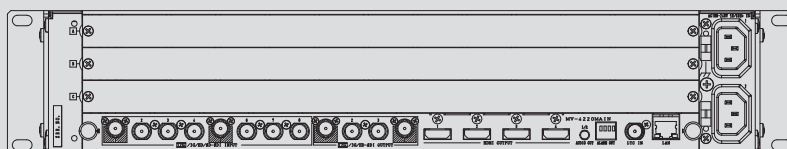
MV-4200



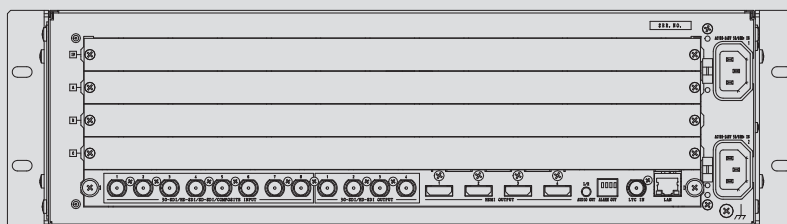
MV-4210



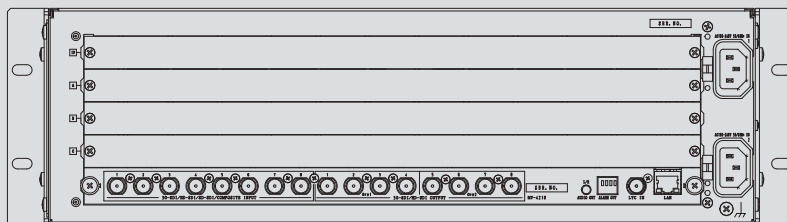
MV-4220



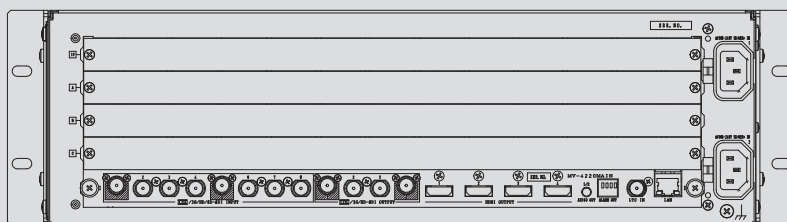
MV-4300



MV-4310



MV-4320





# Specifications

Video format	12G: 2160/59.94p, 2160/50p 3G: 1080/60p, 1080/59.94p, 1080/50p (Level-A/B, 2SI*/SQD) HD: 1080/60i, 1080/59.94i, 1080/50i, 720/60p, 720/59.94p, 720/50p, 1080/30p, 1080/29.97p, 1080/25p, 1080/24p, 1080/23.98p, 720/24p, 720/23.98p, 1080/30PsF, 1080/29.97PsF, 1080/25PsF, 1080/24PsF, 1080/23.98PsF, 1035/60i, 1035/59.94i SD: 525/60 (NTSC), 625/50 (PAL)
Video input	SDI/analog composite switching (Mixed input, asynchronous acceptable)
12G/3G/HD/SD-SDI	12G-SDI: 12.0 Gbps (L-4.5CHD: 50 m max.) 3G-SDI: 3.0 Gbps (5C-FB (Belden 1694A): 70 m max.) HD-SDI: 1.5 Gbps (5C-FB (Belden 1694A): 100 m max.) SD-SDI: 270 Mbps (5C-2V (Belden 8281): 200 m max.) • Quantization: Y: 10-bit, C: 10-bit • Number of 3G/HD/SD inputs: 8 (MV-4200/4210/4300/4310) 6 (MV-4220/4320) 15 (MV-4220SDI) 20 (MV-4200SDI) • Number of 12G inputs: 2 (MV-4220/4320), 5 (MV-4220SDI)
Analog composite	Analog composite: 1.0 Vp-p • Quantization: Y: 8-bit, C: 8-bit • Number of inputs*: 2 (MV-4200/4210/4300/4310), 20 (MV-4200SDI)
HDMI/DVI/RGBHV (MV-4200PCI)	HDMI/DVI • Quantization*: R: 8-bit, G: 8-bit, B: 8-bit, or Y: 10-bit, C: 10-bit (4:4:4) • Resolution PC: 640 x 480, 800 x 600, 1024 x 768, 1280 x 1024, 1366 x 768, 1366 x 768, 1440 x 900, 1680 x 1050, 1600 x 1200, 1920 x 1200, Refresh rate: 60 Hz supported VIDEO (SMPT-E-compliant): DVI-I: 1920 x 1080i/p, 1280 x 720p HDMI: 1920 x 1080i/p, 1280 x 720p, 525/60i, 625/50i Refresh rate: 50/60 Hz supported • HDCP-compliant • Number of inputs: 8 RGB R/G/B: 0.7 Vp-p, HV: TTL • Quantization*: R: 8-bit, G: 8-bit, B: 8-bit • Resolution PC: 640 x 480, 800 x 600, 1024 x 768, 1280 x 1024, 1366 x 768, 1366 x 768, 1440 x 900, 1680 x 1050, 1600 x 1200, 1920 x 1200, Refresh rate: 60 Hz supported VIDEO (SMPT-E-compliant): 1920 x 1080p, 1280 x 720p, Refresh rate: 50/60 Hz supported • Number of inputs: 8
Audio input	12G/3G/HD/SD-SDI (Embedded) • Sampling frequency: 48 kHz (sync to input video signals) • Quantization: 16-bit to 24-bit • 16 channels for each SDI*4 input (4 groups, 8 stereo pairs) Analog (MV-4200IF) Balanced or unbalanced*5, 25-pin D-sub (female), 2 screws • Input impedance: 600Ω/Hi-Z • Input level: -10 dBV/-3 dBu/0 dBu/+4 dBu • Maximum input level (with +4 dBu input level): +24 dBu (balanced), +18 dBu (unbalanced) • Rated input power (with 600Ω termination): +24 dBm • Sampling frequency: 48 kHz • Quantization: 24-bit • Number of inputs: 8 channels AES (MV-4200IF) 75Ω, BNC x 4, unbalanced • Sampling frequency: 32/44.1/48 kHz • Quantization: 16-bit to 24-bit • Number of inputs: 4 (8 channels) HDMI (MV-4200/4220/4300/4320) • Sampling frequency: 48 kHz • Quantization: 16-bit to 24-bit • 8 channels per HDMI input signal LTC input BNC x 1, SMPTE-compliant timecode: within 1.0 Vp-p ±6 dBm
Video output	HDMI (Type-A) • HDMI 2.0 Level B output mode off: 4 standard outputs (4K-compatible output at 3840 x 2160, using Square Division) Quantization: Y: 10-bit, C: 10-bit (4:4:4), or R: 10-bit, G: 10-bit, B: 10-bit (4:4:4) Resolution: 1920 x 1080, 1280 x 720 • In HDMI 2.0 Level B output mode: One 4K-compatible output at 3840 x 2160 Quantization: Y: 8-bit, C: 8-bit (4:2:0) Resolution: 3840 x 2160 • Frequency: 59.94 Hz, 50 Hz • Range: limited • HDCP-compliant 12G/3G/HD-SDI 75Ω BNC 12G-SDI: 12.0 Gbps, 2160/59.94p, 2160/50p 3G-SDI: 3 Gbps 1080/59.94p, 1080/50p (Level-A) HD-SDI: 1.5 Gbps 1080/59.94i, 1080/50i, 720/59.94p, 720/50p • Number of 3G/HD outputs: 4 (MV-4200/4220/4300/4320), 8 (MV-4210/4310) (4K output supported in quad display of 3840 x 2160 signals) • Number of 12G outputs: 2 (MV-4220/4320)
Audio output	Analog Stereo mini jack x 1 (stereo pair x 1/monaural x 2), unbalanced • Output impedance: 100Ω or less • Output level: -10 dBV • Maximum output level: +5 dBV • Sampling frequency: 48 kHz • Quantization: 24-bit Embedded (SDI) • Number of outputs: 4 groups (8 stereo pairs) per output • Sampling frequency: 48 kHz • Quantization: 24-bit Embedded (HDMI) Number of outputs: 4 stereo pairs per output • Sampling frequency: 48 kHz • Quantization: 24-bit Alarm output (relay) 3 types of alarm output: Power 1, Power 2, Fan

Genlock input	• REF IN (MV-4200IF) BB: NTSC: 0.429 Vp-p/PAL: 0.45 Vp-p, Tri-level sync: 0.6 Vp-p 75Ω BNC • INPUT LOCK (selected from MAIN inputs 1-8)
Video input/output delay*6	HDMI*/SDI output Standard: 1 frame to 1.5 frames (for 12G input, 12G output) 1.5 frame to 2 frames (for 12G input, 3G/HD output) 1 frame to 1.5 frames (for 3G/HD/SD input, 3G/HD output) 0.5 frames to 1 frame (for 3G/HD/SD input, 12G output) In delay reduction mode : Select minimum no. of frames for input/output separately.
Video windows	Maximum varies depending on cards used*8
Main unit (8 inputs)	MV-4200/4210/4300/4310: Max. 12 (Multi-window display (up to 12) for standard channels of input) MV-4220/4320: Max. 8 (Multi-window display (up to 8) for standard channels of input)
20 SDI inputs	MV-4200SDI: Max. 34 (Multi-window display (up to 34) for input) MV-4220SDI: Max. 20 (Multi-window display (up to 20) for input)
8 HDMI inputs	MV-4200PCI: Max. 11 (Multi-window display (up to 11) for input)
Information window	• Maximum: 8 • Time based on internal clock or LTC time code • Time correction via GPI or SNTP • Internal clock accurate to within 15 seconds/month (at 25°C)
Count up/down timer*9, Remaining time counter, Schedule timer, Information display	Can be displayed in information window. (Internal clock or LTC is selectable for remaining time counter and schedule timer.)
Background display (with an optional input card)	Store and display two 4K or eight 2K background images • Can be stored on an SDI/PCI input card • Max. size: 3840 x 2160
Logo display	Store and display 8 logo images • Can be stored on the main unit • Max. size: 1024 x 512
Screen layout	User customized layout • Up to 68 layout patterns can be saved.
Title display	Character limit: Max. 16 characters x 2 lines for each input channel Supported characters: • Letters, numbers, symbols, Korean characters and Japanese kana/kanji (JIS 1 and 2) • The multi viewer can convert and save the characters typed on a computer as a logo in bitmap format for later use on the viewer screen.
Tally display	Indicated as a frame (red/green/amber) or marker (red/green/amber) on each input window.
Audio level display	Up to 16 audio channels of audio level metering per input
Time code display	• Display for 3G/HD/SD-SDI ancillary timecode (ATC)*10 • Reader mode*11
Video monitoring	Detects video loss, frozen frames, incorrect luminance/black level, and CRC/HDCP error.
Audio monitoring	Detects audio loss, silence, and excessive audio levels.
Interface (standard)	LAN: 100BASE-TX/1000BASE-T, RJ-45 x 1 (CAT 5e-compliant)
Interface (optional)	Installing MV-4200IF adds the following RS-232C/RS-422/RS-485 9-pin D-sub (male) x 1 • Baud rate: 9600/19200/38400/57600/115200 bps • Data length: 8-bit • Stop bit: 1-bit • Parity: none/odd/even GPIO 80-pin (female) x 2 • Up to 144-pin for input/output (selectable, can be used for input and output) • Five types of alarm output: Power 1/2 operating normally, fan alarm, problem with power 1/2
Layout Manager	Windows® software for customizing window logo sizes and positions, switching windows, and registering backgrounds, logo and text logos (Windows® software)
Live Viewer	Software for video streaming (Windows® software)
Data backup	Stores settings internally to the memory (rewrite capacity: approx. 100,000 times)*12.
Backup battery	Internal lithium battery (to maintain time)
Temperature/humidity	0°C to 40°C / 30% to 90% (no condensation)
Power/consumption	AC 100 V to AC 240 V ±10%, 50 Hz/60 Hz MV-4200/4210/4220: 499 VA (499 W) (at 100 V AC to 120 V AC) 502 VA (476 W) (at 200 V AC to 240 V AC) MV-4300/4310/4320: 657 VA (650 W) (at 100 V AC to 120 V AC) 680 VA (618 W) (at 200 V AC to 240 V AC)
Dimensions/weight	MV-4200/4210/4220: 430 (W) x 88 (H) x 470 (D) mm EIA 2 RU/16 kg MV-4300/4310/4320: 430 (W) x 132 (H) x 540 (D) mm EIA 3 RU/22 kg
Accessories	Quick Setup Guide, Power cable (with outlet tether), Rack mount brackets, HDMI clamps x 4 (MV-4200 only), CD-ROM (Layout Manager, Live Viewer, Layout File, Operation manuals)
Consumables	Cooling fan MV-4200 series (P1505-1, P-1506-1, P-1515, P-1516, P-1517, P-1518, P-1519), MV-4300 series (P-1568, P-1569): Replace every 5 years. Backup battery CR2032: Replace every 5 years Battery: Replace every 5 years
Options	MV-4200PS: Redundant power supply (MV-4200/4210/4220) MV-4300PS: Hot-swappable redundant power supply (MV-4300/4310/4320) MV-4200SDI: 20-input 3G/HD/SD-SDI/Analog composite card MV-4220SDI: 5-input 12G-SDI card or 20-input 3G/HD/SD-SDI card MV-4200PCI: 8-input HDMI/DVI/RGBHV card MV-4200IF: Input of genlock, audio (AES and analog), GPIO (144), and serial control (RS-232, RS-422, RS-485) MV-4200SNMP: SNMP-compatible software 8840S-080-174ADF-150SSH: GPIO cable (1.5 m, stripped) 8840S-080-174ADF-300SSH: GPIO cable (3 m, stripped) HVS-AUX16A/16B/32A/64A: AUX remote panel

\*1 Available on MV-4220/4320 or MV-4220SDI. \*2 Not available on MV-4220/MV-4320 or MV-4220SDI. \*3 Internally converted from 4:4:4 to 4:2:2. \*4 For 3G-SDI Level-B, only Link-A audio is supported, not Link-B. For 12G-SDI, Link 1 to 4 (ch. 01 to 64) are supported. \*5 For unbalanced input, short Cold-Shield externally. \*6 Using interlaced input. \*7 The number of frames for HDMI input/output is equal to that for 3G/HD input/output. \*8 Four windows are used for 4K display. \*9 Stopwatch/timer uses an internal crystal oscillator: ±50 ppm within operating temperature. (0°C to 40°C) \*10 Ancillary time code (ATC) is not passed through. \*11 Time code from LTC input is not displayed. \*12 Frequent setting changes may impair data retention.

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