ARCHITECTURAL SPECIFICATIONS

CORIOMASTER2 (CM2-547-MK2)



Product Overview





CORIOmaster2 (CM2-547-MK2) is a powerful, efficient approach to building large 4K/8K video display systems. Multiple video windows can be positioned on LED, display based videowalls or projector edge blends, displaying any of the sources connected to CORIOmaster2. Windows can be visually "transitioned" into position, resized, or rotated to any proportion allowing designers to achieve striking visual effects. Each system can support up to three separate 4.1 Gigapixel video canvasses with up to sixty-four windows per canvas depending upon the source resolution, frame rate and size of windows. CORIOgrapher, the control software for the CORIOmaster2 series of processors, is a simple, easy to use design interface that enables window and source positioning and transition effects. This dynamic feature is easily managed through presets in CORIOgrapher or by simple commands executed by third party control systems. Fifty presets can be saved permanently in the system.

CM2-547-MK2 is the enhanced model of CORIOmaster2 (CM2-547), which includes an upgraded CPU module, enabling updated firmware and the CORIOgrapher 4.0 software.



CORIOmaster2 (CM2-547-MK2) can accommodate numerous I/O configurations in the eight input and seven output video slots available; when inserted, the modules are automatically recognized & configured. This flexibility allows end user configurations to be based on their own needs.

Key Features and Benefits

- New V Series firmware running on an uprated CPU Allows support of a whole host of new features including 8K with source link.
- Patented CORIO® video processing technology Superior scaling and cross conversions with full source and output rotation and processing to 8K60.
- **752Gbit system bandwidth (360Gbit output bandwidth)** Very high bandwidth system allows for a lot of processing power in a small chassis. Simultaneous processing of up to 28x 4K60 outputs and 20x 4K60 inputs.
- Up to 128 windows per system (40 x 4K60 total) Dedicated windows for every input plus an additional 64 flexible windows that can be switched to any source.
- Up to 64 windows per canvas Allows multiple complicated set-ups on a single canvas.
- Manage up to 3x 4.1 Gigapixel canvases (over 12 Gigapixels of design space) Allows for real world layouts with up to 56 displays available for a single canvas.
- 4RU frame size Incredibly powerful system in a small lightweight footprint for easier shipping and installation
- Modular (8x Video Input Slots, 7x Video Output Slots and 1x Audio Slot Fully customizable to suit the
 requirements of the installation, saves on additional equipment such as DA's or converters that would have many
 more points of failure.
- **Field upgradable (flash, upgradeable via download)** Allows extended system life due to support and feature upgrades that are free of charge for the life of the system.
- Low power consumption when compared to PC based systems Huge savings on cost of ownership over the life of the system as well as reduced need for HVAC.
- Uses CORIOgrapher, an easy to use and powerful software interface Set up can be designed off-line for ease of specification and partially tested without the need to purchase equipment up-front. CORIOgrapher is free to use and very easy to operate to design and configure complicated systems.
- **CORIOgrapher live dashboard to switch presets and window sources** Use CORIOgrapher as a control device to switch presets and sources.
- **Automatically discover device on the network using CORIOdiscover** Easily locate and identify CORIOmaster systems on a network and allow remote firmware updates.
- Simultaneous processing from 4 to 28x 4K60 outputs and 1 to 20x 4K60 Inputs or 8 to 56x full HD outputs
 and 2 to 32x full HD inputs Allows for a single system to run large installations and saves on system and
 running costs.
- Windows and displays can be rotated in 1° increments Allows for complicated installation conditions and creative video walls as well as powerful rotation in transitions. Compensates for poorly installed displays.
- Versatile DVI inputs: (HDMI/DVI/CV/YC/RGB/YPbPr) A full range of available adapters allows inputs from almost any analog source as well as supporting additional HDMI inputs.
- **4K60 input & output modules** Support for high resolution outputs required for high quality video and information displays.
- HDMI outputs: (8x 1080p60 or 4x 4K60 modules available) Allows easy connectivity for high resolution video with audio and HDCP support for a wide range of display types.
- 4K HDBaseT inputs Provide a high-resolution source to CORIOmaster over IP from a remote location using HDBT.
- **SDI inputs SDI, HD-SDI, 3G-SDI, 6G-SDI, 12G-SDI** Perfect for connection to camera equipment and for use in a broadcast environment. Provides fully uncompressed video Inputs at up to 4K60 resolution over a co-axial cable up to 100 metres.



- SDI outputs HD-SDI, 3G-SDI, 6G-SDI, 12G-SDI Perfect for outputs to SDI displays and other equipment and for
 use in a broadcast environment. Provides fully uncompressed video outputs at up to 4K60 resolution over a coaxial cable up to 100 metres.
- Luminance Keying feature available on all outputs Key video, logos and graphics over background video and Pip's. Great for providing information and impact to display outputs that drive direct view LED, separate displays including OLED, LCD and any other type of display device designed for video and or data display as well as video and data projectors.
- **H.264/H.265 4K/30 Streaming Media & 4K Playback Input Module** Up to 8x modules can be used to support simultaneous input of 16x 4K H.264 and H.265 IP streams and connections from up to 40 different encoders.
- Combination of different size and resolution of displays can be used Use different physical size and multiple display resolutions in the same set up and correctly scale and deliver content across these outputs.
- Customizable bezel compensation allow for display bezels and gaps to display contents correctly.
- Multi-edge blending of projectors Large, expansive set-ups using edge blending of up to 56x FHD outputs or 28x 4K outputs.
- **Up-down-cross conversion** Input in any format or resolution that is supported by a module and output in a different resolution and format. Saves on purchase of peripheral equipment that will increase costs and allow for more points of potential failure in a set-up.
- **EDID manager** Required to allow connection to different display types as well as control what is delivered by devices providing input sources.
- **Secure command interface** Ensures secure encrypted connections to a CORIOmaster device, often a critical requirement in many installations.
- **REST API** Allows multiple control devices to connect simultaneously and control a CORIOmaster device. CORIOmaster's API is freely available to allow programming of third-party controllers.
- Real-time status feedback through events (WebSocket's) Allow monitoring and responses to real time events such as a source loss or status change etc.
- Command line interface Direct device connection over LAN or via RS232
- **Crestron Plugin available** Easier set-up of third-party Crestron controllers with preprogrammed elements that control the key features needed. For example, preset triggers, window source switching and audio controls.
- Q-SYS Plugin available CORIOmaster plugin for the Q-SYS control environment to allow fast and easy set up and control of CORIO devices that are installed into a Q-SYS controlled installation.
- IP decoding low latency mode Lower latency processing for H.264 and H.265 sources, input to output
- IP stream labelling Easily identify streams by automatically displaying the filename or add a friendly name.
- Audio support (one stereo pair per canvas) Support audio in one device removing the need to add peripheral equipment.
- Audio module to embed and de-embed audio Input of digital or analog audio (x1). Output of analog (x1) and digital audio (x3)
- Custom resolution editor Engine for the set-up of custom resolutions for inputs and outputs. Useful for DVLED set-up's
- Frame lock and sync lock Ensure that everything is in sync by using a reference video input and/or internal reference clock.
- 8HD synchronized playback Used with a media streaming and playback module. One module can provide 8x FHD outputs in perfect sync which removes the need for 8 separate source inputs to a system. Up to 8x media modules can be fitted, providing up to 64x HD media playback.
- Source link (2x2, 4x1, 1x4) for 8K windows New 8K source windows can take a grouped input from 4x 4K60 to provide a seamlessly stitched and synchronized 8K source. 4K sources can be scaled to 8K for source switching.



- Fade to black window setting Source windows can be faded down to black or any luminance value and this
 can be controlled from a preset. Use to highlight a particular source by partly fading others or as a fade transition
 at the end of a segment.
- Window fader (when used with keying feature) Use the fade to black window feature in combination with the keyer to provide a true fade. Provides a crossfade experience when used with another background source.

Options

Dual redundant hot swappable power supply (load balanced)

Universal DVI adapters

Air inlet filter (Stainless Steel lifetime re-usable type)

Onsite and remote system commissioning (on-site is US Only)

Chassis and Optional modules

CM2-547-MK2 4RU CORIOmaster2 chassis

CM2-3GSDI-4IN 3G-SDI input 4x

CM2-AVIP-IN-1USB-1ETH-128 4K Media Streaming Input 128GB SSD

CM2-DVIU-2IN DVI-U input 2x (DVI, RGB/YUV, CV, YC via DVI-I)

CM2-HDMI-4IN HDMI 1080P input 4x

CM2-HDMI-4K-2IN HDMI 4K input 2x

CM2-HDBT-2IN-1ETH HDBT input 2x (and single ethernet)

CM2-AUD-2IN-3OUT Audio I/O module - analogue (1xIN, 1xOUT), SPDIF (1xIN, 3xOUT) via terminal block

CM2-HDMI-4K-4OUT HDMI 4K output 4x

CM2-HDMI-HD-8OUT HDMI 1080P output 8x

CM2-BONDING Bonding Module

CM2-12GSDI-4IN 12GSDI input 4x

CM2-12GSDI-4OUT 12GSDI output 4x

CM2-4RPS Optional dual redundant, hot swappable power supply 400W

CM2-4RPS-700 Optional dual redundant, hot swappable power supply 700W

Requirement Specification

- 1. Video processors must include a free **5-year warranty** with system support for 5years after discontinuance of the product. Video processors that do not include a free 5-year warranty with system support for 5years after discontinuance of the product will not be accepted.
- 2. Video processors must have an **OLED display visible at the front and capable of displaying its IP address and status information**. Video processors that do not have an OLED display visible at the front and capable of displaying its IP address and status information will not be accepted.
- Video processors must use free of charge dedicated configuration software CORIOgrapher to specify and set-up the video processor. Video processors that do not use free of charge dedicated configuration software CORIOgrapher to specify and set-up the video processor will not be accepted.
- 4. Video processors must use free of charge dedicated configuration software CORIOgrapher that has an offline mode where a set-up can be configured and checked prior to purchase of the hardware. Video



processors that do not use free of charge dedicated configuration software CORIOgrapher that has an off-line mode where a set-up can be configured and checked prior to purchase of the hardware will not be accepted.

- Video processors must support cross conversion of the following signals: DVI, HDMI, VGA, Component, Composite, YC, SD-HDI, HD-SDI, 3G-SDI, HDBaseT. Video processors that do not support cross conversion of the following signals: DVI, HDMI, VGA, Component video, Composite, YC, SD-HDI, HD-SDI, 3G-SDI, HDBaseT. Video processors that do not support cross conversion of DVI, HDMI, VGA, Component, Composite, YC, SD-HDI, HD-SDI, 3G-SDI, HDBaseT will not be accepted.
- Video processors must support up/down conversion of the following signals: DVI, HDMI, VGA, Component, Composite, YC, SD-HDI, HD-SDI, 3G-SDI, HDBaseT. Video processors that do not support up/down conversion of DVI, HDMI, VGA, Component, Composite, YC, SD-HDI, HD-SDI, 3G-SDI, HDBaseT will not be accepted.
- 7. Video processors must support **serial control via RS-232**. Video processors that do not support serial control via RS-232 will not be accepted.
- 8. Video processors must support **network control via RJ45**. Video processors that do not support network control via RJ45 will not be accepted.
- 9. Video processors must support **scaling on all outputs**. Video processors that do not support scaling on all outputs will not be accepted.
- 10. Video processors must have no more than **typically 1 and maximum 2 frames of latency** input to output. Video processors that allow more than typically 1 and maximum 2 frames of latency input to output will not be accepted.
- 11. Video processors must be a **modular based system** allowing for multiple configurations of Video input and output modules. Video processors that do not allow for multiple configurations of Video input and output modules will not be accepted.
- 12. Video processors will provide 17 video slots for modular configuration where 8 will have dedicated use as an input and 7 will be dedicated as outputs. A separate slot dedicated for auxiliary use and a separate slot for a CPU. Video processors that do not provide 17 video slots for modular configuration where 8 will have dedicated use as an input and 7 will be dedicated as outputs. A separate slot dedicated for auxiliary use and a separate slot for a CPU will not be accepted.
- 13. Video processors must be able to manage **3 independent, simultaneous, canvases each of 64,000 x 64,000 pixels with one chassis**. Video processors that do not manage 3 independent, simultaneous, canvases each of $64,000 \times 64,000$ pixels with one chassis will not be accepted.
- 14. Video processors must support at least **64 simultaneous, video channels per canvas**. Video processors that do not support at least **64 simultaneous**, video channels on each canvas will not be accepted.
- 15. Video processors must support **1-360° rotation on each video source**. Video processors that do not support 1-360° rotation on all video sources will not be accepted.



- 16. Video processors must support **1-360° rotation on every Output**. Video processors that do not support 1-360° rotation on every output will not be accepted.
- 17. Video processors must be **FPGA** based, allowing for **FW** upgrades to add new functionality and features.

 Video processors that are not FPGA based allowing for FW upgrades to add new functionality and features will not be accepted.
- 18. Video processors must support **different size and resolutions of displays within each set-up**. Video processors that do not support different size and resolutions of displays within each set-up will not be accepted.
- 19. Video processors must support **video projector edge-blending on every output**. Video processors that do not support video projector edge-blending on every output will not be accepted.
- 20. Video processors must be **HDCP compliant with all DVI and HDMI inputs and outputs**. Video processors that are not HDCP compliant with all DVI and HDMI inputs and outputs will not be accepted.
- 21. Video processors must have a **minimum of 50 programmable presets per system**. Video processors that do not have a minimum of 50 programmable presets per system will not be accepted.
- 22. Video processors must provide **preset driven transitions**. Video processors that do not support preset driven transitions will not be accepted.
- 23. Video processors must have **programmable presets that include the ability to select specific windows and choose between layout only or layout and sources**. Video processors that do not have programmable presets that include the ability to select specific windows and choose between layout only or layout and sources will not be accepted.
- 24. Video processors must support **4K60 Video sources**. Video processors that do not support **4K60 video** sources will not be accepted.
- 25. Video processors must support **4K60 outputs**. Video processors that do not support 4K60 outputs will not be accepted.
- 26. Video processors must allow for **8K processing via source linking of 4x 4K60 sources**. Video processors that do not allow for 8K processing via source linking of 4x 4K60 sources will not be accepted.
- 27. Video processors must have cooling fans that are automatically and intelligently controlled by detecting changes in temperature of the circuitry inside the unit, helping to keep the unit cool and improve reliability. Video processors that do not have cooling fans that are automatically and intelligently controlled by detecting changes in temperature of the circuitry inside the unit, helping to keep the unit cool and improve reliability will not be accepted.
- 28. Video processors must support **luminance keying for any source window and across all outputs**. Video processors that do not support luminance keying for any source window and across all outputs will not be accepted.



- 29. Video processors must have **dual redundant and hot-swappable power supplies**. Video processors that do not have dual redundant and hot-swappable power supplies will not be accepted.
- 30. Video processors must allow **control via 3rd party controllers using API**. Video processors that do not allow control via 3rd party controllers using API will not be accepted.
- 31. Video processors must **require no more than 700 watts of power when fully fitted with expansion modules and accessories**. Video processors that require more than 700 watts of power when fully fitted with expansion modules and accessories will not be accepted.
- 32. Video processors must support **secure communication HTTPS**. Video processors that cannot support secure communication HTTPS will not be accepted.
- 33. Video processors must **support REST API** providing multi-user communication to device. Video processors that cannot support REST API providing multi-user communication to device will not be accepted.
- 34. Video processors must support subscribing to events using WebSocket's providing real time feedback to automatically monitor the operation of the video processor and respond accordingly. Video processors that cannot support subscribing to events using WebSocket's providing real time feedback to automatically monitor the operation of the video processor and respond accordingly will not be accepted.
- 35. Video processors must support **embedded audio through the system from source to display**. Video processors that cannot support embedded audio through the system from source to display will not be accepted.
- 36. Video processors must support the **de-embedding of 2 channel audio from any input source and in digital or analog format via an optional audio module**. Video processors that cannot support the de-embedding of 2 channel audio from any input source and in digital or analog format via an optional audio module will not be accepted.
- 37. Video processors must support **Input and output volume control together with audio mute**. Video processors that cannot support Input and output volume control together with audio mute will not be accepted.
- 38. Video processors must support up to up 56 discrete 1080p displays with ability to place these displays in any orientation. Video processors that cannot support up to 56 discrete 1080p displays, with ability to place these displays in any orientation will not be accepted.
- 39. Video processors must support up to 28 discrete 4K60 displays with the ability to place these displays in any orientation. Video processors that cannot support up to 28 discrete 4K60 displays with the ability to place these displays in any orientation will not be accepted.
- 40. Video processors must have **set up software that allows for the creation of custom input and output resolutions**. Video processors that do not have set up software that allows for the creation of custom input and output resolutions will not be accepted.
- 41. Video processors must have a provision either as an optional accessory or provided with the unit that **restricts** dust ingress through its cooling fans by using a stainless steel, lifetime use air filter. Video processors that



do not have a provision either as an optional accessory or provided with the unit that restricts dust ingress through its cooling fans by using a stainless steel, lifetime use air filter a provision either as an optional accessory or provided with the unit that restricts dust ingress through its cooling fans by using a stainless steel, lifetime use air filter will not be accepted.

- 42. Video processors must support IP video decoding of H.264 (Main, High), MPEG4, H.265/HEVC (Main). Video processors that do not support IP video decoding of H.264 (Main, High), MPEG4, H.265/HEVC (Main) will not be accepted.
- 43. Video processors must support at least **16 streams of IP video up to 50Mbit H264, 25Mbps H265 per stream** (dual stream) in a single chassis. Video processors that do not support at least 16 streams of IP video up to 50Mbit H264, 25Mbps H265 per stream (dual stream) in a single chassis will not be accepted.
- 44. Video processors must support **IP resolutions up to 3840x2160/30fps**. Video processors that do not support IP resolutions up to 3840x2160/30fps will not be accepted.
- 45. Video processors must support **RTSP**, **RTMP**, **HTTP**, **MPEG-TS Unicast Streams**. Video processors that do not support RTSP, RTMP, HTTP, MPEG-TS Unicast Streams will not be accepted.
- 46. Video processors must support **RTSP**, **MPEG-TS Multicast Streams**. Video processors that do not support RTSP, MPEG-TS Multicast Streams will not be accepted.
- 47. Video processors must have internal media file storage of at least 128 Gb using a single expansion module. Video processors that do not have internal media file storage of at least 128 Gb using a single expansion module will not be accepted.
- 48. Video processors must be able to playback file types mp4, mov, mkv, m4v, ts, mts, m2ts, mt2, mpeg2 from memory provided by a single expansion module. Video processors that cannot playback file types mp4, mov, mkv, m4v, ts, mts, m2ts, mt2, mpeg2 from memory provided by a single expansion module will not be accepted.
- 49. Video processors must be able to copy media from an external storage device to internal memory for playback and be able to play media files directly from an external storage device. Video processors that cannot copy media from an external storage device to internal memory for playback and be able to play media files directly from an external storage device will not be accepted.
- 50. Video processors must have **FCC**, **CE**, **RoHS**, **ULc compliance**. Video processors that do not have FCC, CE, RoHS, ULc compliance will not be accepted.



Full Technical Specifications

Video Processing Power

Parallel Processing Architecture Yes
CORIO Video Processing Yes
Up/Down/Cross Conversion Yes
Number of Canvasses 3

Display Size Compensation Yes, different sizes in video walls*1

Output Rotation Yes, for any outputs and windows

Projector Edge Blending Yes
HDCP Key Handling Yes

Video Inputs

Analog Up to 16x via Universal DVI, Format RGBHV, RGBS,

RGsB, YPbPr

Composite Video - Up to 16x via DVI-U

YC (S-Video) - Up to 16x via DVI-U YUV /YPbPr - Up to 16x via DVI-U

Television Standards - NTSC, PAL

Digital DVI Up to 16x via Universal DVI (HDMI & HDCP compatible)

HDMI Up to 32x (HDCP compatible)

4K HDMI up to 24x 4K30, 20x 4K60 or 4x 8K (quad 4K60)

grouped sources

HDBaseT + Ethernet Up to 8x 4K30 plus 8x 1080p/30 plus 8x ethernet via

R.J45

3GSDi Up to 32x 1080P/60 via BNC

IP Up to 16x 1080P/30 or 8x 4K30 plus 8x 1080p/30 (IP

Stream)

Supported Input Resolutions (depends on modules fitted)

(640x480p) 60/72/75/85Hz

(720x487i) 59.94Hz

(720x480i) 59.94Hz

(720x480p) 59.94Hz

(720x576i) 50Hz

(800x600p) 56, 60, 72, 75, 85Hz

(980x980p) 75Hz

(1024x768p) 60, 70, 75, 85Hz

(1152x864p) 70, 75Hz

(1280x720p) 23.98, 24, 25, 29.97, 30, 50, 59.94, 60Hz*2

(1280x768p) 60, 75, 85Hz (1280x800p) 60, 75, 85Hz



(1280x960p) 60, 85Hz

(1280x1024p) 50, 60, 75, 85Hz

(1360x768p) 60Hz

(1366x768p) 60Hz

(1400x900p) 60Hz

(1400x1050p) 50, 60, 75Hz

(1440x900p) 60, 75, 85Hz

(1600x900p) 60Hz

(1600x1200p) 60Hz

(1680x1050p) 60Hz

(1920x720p) 50, 59.94, 60Hz

(1920x1080i) 47.96, 48, 50, 59.94, 60Hz

(1920x1080p) 23.98, 24, 25, 29.97, 30, 50, 59.94, 60, 120Hz

(1920x1200p) 50, 60Hz

(3840x2160p) 23.98, 24, 25, 29.97, 30, 50, 59.94, 60Hz (4096x2160p) 23.98, 24, 25, 29.97, 30, 50, 59.94, 60Hz

Video Outputs

HDMI Up to 56x 1080P/60 HDCP 2.2 compatible

4K HDMI Up to 28x 4K60, HDCP 2.2 compatible

Size and Position User Adjustable

Conversion Technology Proprietary CORIO®

Color HDMI 24-bit 4:4:4

Supported Output Resolutions (depends on modules fitted)

(1280x720p) 50, 60Hz

(1920×1080i) 50, 60Hz

(1920x1080p) 23.98, 24, 25, 29.97, 30, 50, 60, 119.88, 120Hz

(3840x2160p) 23.98, 24, 25, 29.97, 30, 50, 59.94, 60Hz

AV over IP (up to 8x module cards)

Interface 1 x GbE Ethernet Port

IP Video Decoding H.264 (Main, High), MPEG4, H.265/HEVC (Main) 8-bit

IP Bit Rates Up to 16x streams up to 50Mbit H264, 25Mbps H265 per stream (dual stream)

Color Depth 4:2:0, 4:2:2

Supported IP Resolutions Configurable to 3840x2160p/30 Unicast Streams RTSP, RTMP, HTTP, MPEG-TS

Multicast Streams RTSP, MPEG-TS



Media/Images

Still Image JPEG, PNG, BMP

Interfaces Up to 8x USB3.0, Internal Storage, Network
Video Codecs H.264 (CBP, Main, High), H.265/ HEVC (Main)
Video Formats mp4, mov, mkv, m4v, ts, mts, m2ts, mt2, mpeg2

Playback Bit Rates (Streaming and Media Playback) H264 total data handling 100Mbs, single

channel up to 50Mbps @4K30 (2nd render HD). H265 total data handling

50Mbps, single channel up to 25Mbps @4K30 (2nd render HD)

File Playback Resolutions Supported

Media Handling

External Up to 8x USB 3.0 interface

Supported devices Flash file systems FAT, FAT32, ext3, ext4, NTFS.

Internal High-speed storage up 128GB per module

Remote File transfer supported.

Control Methods

RS-232 via D9 Female Connector

IP Interface RJ45 Connector for both HTTP(s)

CPU Module

Settings Memory Non-Volatile

Warranty

Limited Warranty 5 Years Parts and Labor

Regulatory Compliance

Main unit FCC, CE, RoHS, ULc



Mechanical

Size (H x W x D) 7.0" x 17" x 12.09", (178mm x 432mm x 307mm), (D) including PSU Handle

12.99" (330mm), (W) including rack ears 19" (483mm)

Weight (Net) Approx. 22lbs (10Kg) Chassis Without Modules but included 1x Power Supply

Environmental Operating Temperature 32° to 104°F (0° to +40°C)

Operating Humidity 10% to 85%, non-condensing Storage Temperature 14° to +158°F (-10° to +70°C)

Storage Humidity 10% to 85%, Non-condensing BTU 1365 BTU (400W), 2390 BTU (700w)

Fan Noise 32 to 64 dB

Power

Internal Power Supply 100v to 240v auto-detecting

Redundancy Optional Internal Hot Swap PSU with load balancing.

Consumption 400W or 700W depending upon version.

Specifications subject to change *1 using different sized monitors in the same wall can degrade picture quality *2 DVI input module only supports 720p frame rates 50, 59.94 & 60Hz