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**STREAMLINING STUDIO  
PRODUCTIONS:**

# Direct Camera Head Connections with ST 2110 Technology



Panasonic has been utilizing IP protocol to control cameras, including studio system cameras, camcorders, and PTZ, for years. Over that time, IP versions of tally, intercom, and video transport have matured across all levels of the AV industry. Because the primary role of the studio camera base station or camera control unit (CCU) is to connect the camera system to other production networks, it should be possible to bypass the CCU and connect necessary camera functions directly to the networks. This paper explores how this has been accomplished with the AK-HC3900, AK-PLV100 and the new AK-UCX100 and how it might impact future cameras.

## What Makes a System Camera?

Like the radio broadcasts that preceded them, the first live TV broadcasts were performed on a stage. Because there were no zoom lenses and cameras were difficult to move, multiple cameras were used to focus on different people and spaces in the show. This setup simulated the multiple camera angle editing vocabulary audiences were accustomed to from years of movie theater attendance.

The electronics required to create a video signal initially did not fit in a camera chassis and required a significant amount of electrical power. The cameras in the studio space were mostly optics and vacuum tubes, with most video electronics housed in a separate machine room. This resulted in bulky cables between camera heads and the machine room. Like early lighting systems of the day, these setups posed a real risk of electrocution, making safety standards essential. Crews today still benefit from those standards.

Connections between the camera and base station included signals from the picture tubes, high voltage, low voltage, reference signals, and other connections to support electronics. Multicore cables, including coaxial lines, twisted pairs of copper wire, and other connections, formed an integrated connectivity system between the camera head and the rest of the system. These cables also provided tally signals and other communications required by the production team.

As smaller electronics like transistors and integrated circuits made it possible to process more of the video image in the camera head, the cables could be simplified. However, they still needed to provide power and send prompter and program video back to the camera. Triaxial cable and later fiber optic hybrid cables (ST 311) provided both AC power and bandwidth to send video in both directions, muxed with intercom and other communication requirements. The new cables allowed the base station or CCU to serve as both a power source and a connection hub for all the video and communication systems in the production.

Many systems with particularly long cable runs now separate the fiber optic data lines from the power and reinsert power closer to the camera. In this instance, the entire connection is a pair of single-mode fiber lines between the camera and CCU.

# Camera Control Unit (CCU) Connections

The CCU, connected to the camera via a single cable, acts as a hub to link the camera to all the necessary systems required to operate a live multi-camera production. These include:

- **Sync signal:** Available in both digital and analog versions, syncing is necessary to ensure all cameras start each new frame scan simultaneously, allowing for seamless cuts and fades between cameras.
- **Tally:** One or more flags from a switcher enable on-screen talent to focus on whichever camera is "live" at any given time.
- **Control/Paint:** Connects cameras to a controller designed to adjust camera settings to match exposure, color, and other attributes, ensuring seamless transition between cameras.
- **Intercom:** A communication system running to every camera, enabling the camera operators, technical director, and director to work together and select appropriate camera angles for the story.
- **Audio:** Captures natural or ambient sound if the camera is using a microphone.
- **Return Video:** Any video can be fed back to the camera operator's viewfinder, including the final show cut, camera with a key added, other cameras, etc.
- **Teleprompter:** A video signal from a teleprompter system feeding a teleprompter on the camera.
- **Video Trunk:** An auxiliary video line into the camera and out of the CCU.
- **Data & IP Trunk:** Other data links from camera to the CCU and vice versa.

The size of a typical CCU is 2U or 4U and either full rack or half rack, making the chassis large enough to hold the camera power supply and all the above connection points. The Panasonic AK-UCU700 series not only provides all these connections but also adds several new IP connections for alternative IP-based versions.

- NP701 option provides a 25G connection to a ST 2110 network, which includes uncompressed and compressed video and audio essence, as well as an IP sync system (precision time protocol [PTP]).
- NP702 option provides connectivity to an IP-based Dante audio system for audio or intercom use.
- NP703 option provides streaming SRT or NDI for video signals in or out.



# IP Versions of CCU Connections

In past decades, IP versions of the connections described above have been developed, including:

- ST 2110 for large router systems includes transport for the following:
  - Video essence, including HD and 4K with sub-frame latency. This works like SDI but is multicast and typically requires a 10G network or more due to uncompressed content.
  - AES67 audio spec is part of the ST 2110 essence.
  - PTP provides sync for all ST 2110 devices or can sync to a traditional clock.
  - ST 2110 can be used for video out, return, and any video trunk in any direction.
- IP Tally protocols such as TSL.
- Camera control protocols over IP: All current Panasonic PTZ and studio cameras can be controlled via a Gb Ethernet connection. The ROP devices like the AK-HRP1010 can connect to the IP port of the CCU or directly to the network connection of the camera.
- Dante Audio: Works over a Gb Ethernet or higher and works for both intercom and audio for some Panasonic cameras.
- NDI & SRT streaming protocols can be used for both streaming output as well as return video or teleprompter.

With all these connections available over a 1 Gb, 10 Gb, or a 25 Gb IP connection, it is possible to connect a camera head directly to all the CCU functions over a set of IP ports. As mentioned earlier, power insertion devices can be deployed near a camera, connecting the hybrid fiber cable to a device that inserts power for the camera and passes through the single-mode fiber lines. Since these fiber lines can connect directly to an IP network switch by selecting the correct fiber data SFP for the switch to match the camera, this connection can serve as the network connection that provides access to all the above-mentioned IP ports.

With all these connections available over a 1 Gb, 10 Gb, or possibly a 25 Gb IP connection, it is possible to connect a camera head directly to all the CCU functions over a set of IP ports.

# ST 311 Hybrid Fiber Cable for IP Data Transport

Most current studio system cameras connect the camera to the CCU via a hybrid fiber cable as defined by the SMPTE spec ST 311 (or ST 311M). This cable has two single-mode fiber lines and four copper lines. The copper wires carry camera power and provide an option for analog intercom connectivity, while the fiber optic lines carry all other data and analog signals required for the system. The exact nature of these is unique to each camera design. IP networks use various physical links for data transport, including copper wire (e.g., CAT 6) and single-mode or multi-mode fiber, so a camera manufacturer can choose to replace the proprietary muxed signals on the fiber with an IP data connection.

In the case of the Panasonic AK-HC3900 and the AK-PLV100, the fiber optic SFP feeding the ST 311 connector (LEMO Connection in U.S.-sold cameras) is a repurposed 10G IP data SFP. Therefore, it is possible to run the AK-HC3900 and AK-PLV100 in an IP data mode. To activate this function, the activation key AK-SFC391Z is required for the AK-HC3900. The AK-PLV100 will enable this function in late 2024. In network mode, the fiber connections become data ports.

AK-UCX100 connects 25Gb Data SFP to Lemo connector



## Adapting Studio Camera Connections to the Network

Connecting to the network requires first adapting the fiber connections from the ST 311 to "dry fiber" via a passive adapter and powering the camera locally through the 12V power port or by using a power insertion device like the Multidyne HUT. In either case, the fiber will terminate to an LT or ST style fiber connector. From there, a single mode fiber line can be used to connect to the network. Note that data networks typically use multi-mode fiber, but studio cameras use single-mode fiber, and single-mode fiber data SFP are available. Network switches have empty SFP cages, allowing for the physical link to be selected by choosing the appropriate SFP type. To link the HC3900 or PLV100 to the network switch, a single-mode fiber 10G data port should be selected, and the lines terminated to the correct connection.

The 10G single-mode fiber SFP should be compatible with a 100G, 25G, or 10G IP switch when properly configured. Future cameras with 25G data capacities would require a 25G SFP for the switch as well.

AK-CFA100 Camera Fiber Adapter provides power and adapts LEMO to "dry" LC fiber



## Internet Connections and Individual Ports

When used as a 10G data SFP, the fiber connection in the AK-HC3900 functions like a NIC card. This connection is not limited to a single IP address and can be used as several ports. Part of the advantage of ST 2110 is that the video essence, audio essence, and metadata can all be assigned to different IP addresses. Even when not used in ST 2110 mode, the Panasonic AK-HC3900 and AK-PLV100 have an RJ45 port which can be used to connect to the ROP and connect to network-based tally signals. These same ports can be accessed alternatively via the fiber connection alongside the ST 2110 ports.



## Capabilities of a CCU-less Camera System

Once camera power has been provided, and ST 2110 network and additional control networks have all been established, most of the camera capabilities are present.

- Camera output is available on the ST 2110 network although this is limited to 3G HD because UHD would require more bandwidth than 10G. Note that the PLV100 is planned to offer compressed UHD output via JPEG XS.
- PTP on the ST 2110 network will provide camera sync.
- ST 2110 sources on the network can be selected for return video or prompter feed.
- Tally and camera control can be attached on a separate port and accessed through the initial ST 2110 switch connection. Panasonic studio cameras as well as PTZ can also address control on the ST 2110 network.

If cameras are being deployed with an ST 2110 native KAIROS system, such a configuration means that not only are CCUs not required but ST 2110 gateways are not required because the cameras are native ST 2110. In other words, a 100G switch connected to a KAIROS core (via a QSFP) can simply connect to AK-HC3900 or AK-PLV100 cameras by installing 10G single mode fiber SFP in the cages on the same switch.

## Other Cameras and ST 2110 devices

The AW-UE160 PTZ camera is also capable of attaching directly to an ST 2110 network, and of course the AK-UCU710 CCU could likewise be attached to that same network for connection with other Panasonic studio cameras. More ST 2110 native cameras and other devices are planned in the years ahead. These additions to support for SDI will continue to increase system flexibility.



For more information please visit:  
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