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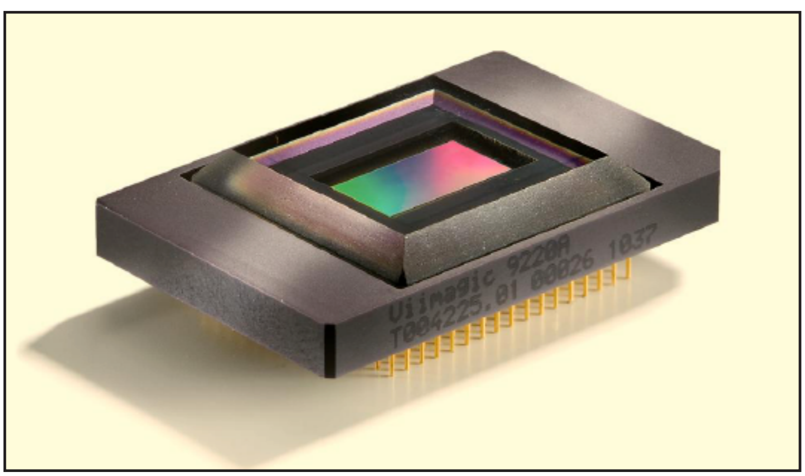
New Trends and Implementations in Imaging Technology for the Future of Live Production

Xensium-FT Imagers, Third-Generation Transmission Solutions and LDX Series Camera Systems

WHITE PAPER



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With ever-increasing momentum, image acquisition for broadcast must adapt to new requirements for supporting signal formats. These include having to support live event progressive formats, increasing number of cameras and increasing distances between cameras and control points.

Sophisticated audiences across wider distribution points are also forcing broadcasters to identify ways to improve the quality of their content to increase its value. In response to increased resource constraints, remote production is steadily being considered as an alternative. With budgets not increasing in proportion, greater efficiency and more flexible equipment is necessary to respond to industry changes over greater periods of time.

Delivering exceptional image acquisition solutions, Grass Valley, a Belden Brand, offers Xensium-FT imagers with the only lossless 1080p imaging that maintains full sensitivity. Grass Valley 3G Transmission systems are the most flexible and future-proof transmission solutions available that also offer direct integration with third-party long distance transmission systems. Camera system integration for other live production components such as switchers and servers, as well as third-party interfacing, is enabled by the networked Connect Gateway. The LDX Series is a camera platform that offers an upgrade and enhancement path based on software upgrades.

Comparison of CMOS and CCD Technology

While CCD technology was the best choice for imagers in broadcast applications for many years, the latest generation of CMOS imagers now offers a range of advantages over CCD. This includes better sensitivity, lower power consumption, less heat and higher integration, with the potential for higher resolution, extended dynamic range and higher frame rates in the future. CMOS is setting the new standard for high-end broadcast applications. A more detailed explanation about the differences between CMOS and CCD imaging technology follows.

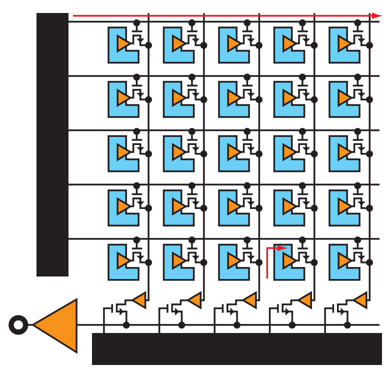
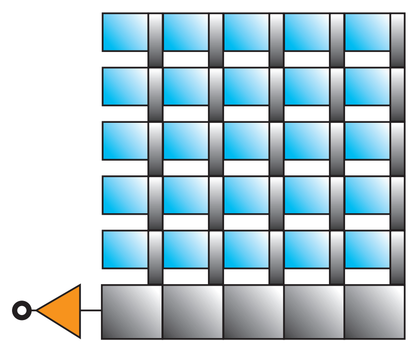
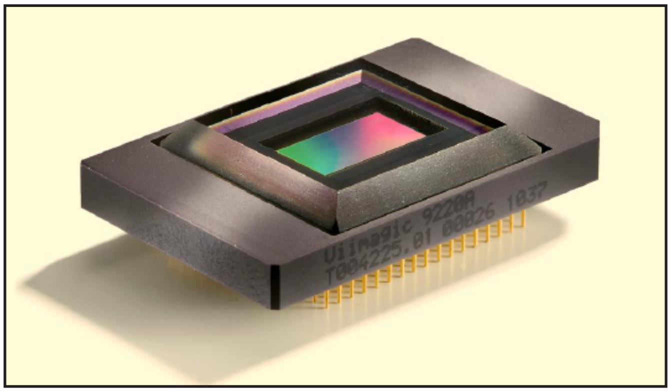
Design	Xensium-FT CMOS	IT CCD
CMOS – Grass Valley: • Low internal clocking speed • Direct addressing of pixels • No overflow • No lag • Multiple A/D converters, timing and read-out circuits integrated on chip IT CCD: • High internal clocking speed • Higher temperature, more noise • Vertical smear because of transport column in image section • External A/D converter • External driver and clocking circuits	 **Xensium-FT CMOS:** The charge of each pixel is sampled individually in each pixel and converted to a voltage. The voltages of each pixel are addressed through a matrix and sent to .the output. This process does not need much energy. Low power consumption. Low heat.	 **CCD:** The charge of each individual pixel is moved through the CCD to a single sample and hold where it is converted from a charge to a voltage. This process needs a lot of energy and produces much heat.

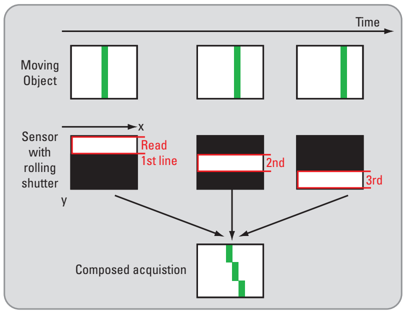
Figure 1 – Structure of Imagers.

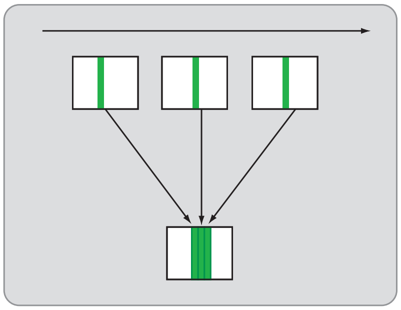
Xensium-FT Imagers: A Superior Replacement for CCD Technology

Some may find the title of this section to be a strong statement. Surely, CMOS imagers are widely used in many camera applications today, but in broadcast cameras they have not seen wide use. But, nearly all still cameras and camera phones have been using CMOS imagers for some years. So do the latest breed of 35 mm-equivalent digital cinematography cameras. The commonality among these devices is that they offer very high resolutions and are based on single chip designs with color separation on the chip — usually by means of the Bayer pattern. Grass Valley believes in 3-imager acquisition and that the current generation of CCDs found in system cameras is the last, and they will now be replaced by a new generation of CMOS imagers.

Since its broadcast camera introduction in 1987, CCD technology has experienced significant developments, but for some time, it has been clear that CCDs have reached their practical limits and large improvements can no longer be expected. Conversely, there is undisputable potential with CMOS imagers in broadcast applications regarding improvements around faster readout for super slow-motion applications, extended dynamic ranges, higher resolutions and lower noise. Up until now, these potential advantages have been offset by the disadvantages of the rolling shutter which was present with all CMOS imagers used in broadcast applications. These effects have been over-exaggerated by some manufacturers, mainly because they need to protect investments in aging CCD technology. Additionally, most of the potential benefits of CMOS imaging technology were not yet applicable to broadcast applications. Today, the technology landscape of CMOS imagers for broadcast has changed. The latest improvements in CMOS imaging have solved the rolling shutter issue completely while keeping the advantages of CMOS technology. They also offer a new level of image performance unmatched by any other imager currently available. There is now a compelling story surrounding CMOS imagers as a replacement for CCDs. A more detailed description of the behavior of the rolling shutter and the global shutter follows.



<table>
<tr><th>Design</th><th>Regular CMOS</th><th>Xensium-FT CMOS / IT CCD</th></tr>
<tr>
<td>There are two different types of exposure:
Regular CMOS: Line-by-line scanning
Xensium-FT / IT CCD: Frame exposure
Each has its own characteristics.</td>
<td>

The rolling shutter of the regular CMOS imager produces images similar to scanning from a Plumbicon tube, because of line-by-line scanning. Shorter exposure times will increase the visibility of the skewing effect as motion blur gets smaller.</td>
<td>
The global shutter of the Xensium-FT CMOS and IT CCD each expose a frame by 1/50 or 1/60 of a second. Shorter exposure times can be used to get sharper pictures and will not produce any visible rolling shutter effect.</td>
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</table>

Figure 2 – Scanning Methods.

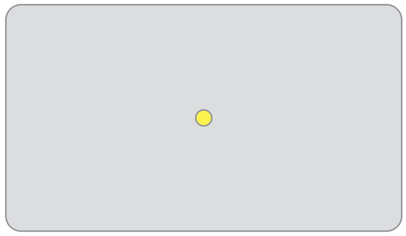
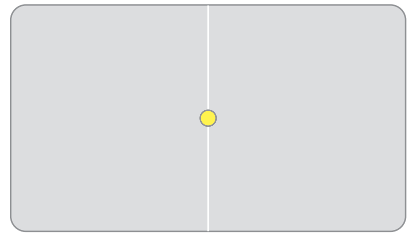
Circumstance	Xensium-FT CMOS	IT CCD
Indoor: • Spot lights • Shining jewelry Outdoor: • Shot into sun • Reflections on water	 No highlight smear under any condition.	 Specification of smear level is typically around -135 dB. But smear becomes much more noticeable when shorter exposure times are used: at 1/2000 sec. smear level is only around -100 dB.

Figure 3 – Extreme Lighting.

The difference in imager design shows a remarkable difference in performance under extreme highlight conditions. The IT CCD, because of its design with transport columns in the image part, shows overflow effects with highlights that are visible as white or even colored vertical stripes on top and under the highlight. A typical vertical smear level is -135 dB which means that it is not visible in many applications, but if IT CCDs are switched to short exposure times, such as for sports events in daylight conditions, this vertical smear effect can get really visible if there are highlights in the scene.

CMOS imagers, because of their structure, will never show any highlight smear or streaking effects.

3T Pixels versus 5T Pixels: Why is it Important?

The CMOS imagers used up to now in broadcast applications — including the Grass Valley LDK 3000 cameras — have used 3T pixels. This means each pixel has three transistors. In these pixels, a photo diode converts the incoming light (photons) into a signal charge (electrons). This signal charge is stored inside a floating diffusion capacitor which is directly connected to the photo diode. A transistor (the SFT transistor in the middle), which is directly connected to the photo diode and the floating diffusion capacitor, converts the signal charge into a voltage. A second transistor (the SEL transistor on the right) switches the signal to the output for readout. After the signal readout, the third transistor (the RST transistor on the left) will then reset the photo diode and the floating diffusion capacitor so that the next exposure time can start. Since there is no room for an in-pixel memory, it becomes clear that the exposure time and the readout time cannot be separated from each other in a 3T pixel design. Since the pixels have to be read out one after the other, every pixel has a different start and end of exposure time. Therefore the CMOS imagers using 3T pixels will always exhibit a rolling shutter behavior.

The new Xensium-FT imagers from Grass Valley are based on a 5T pixel design (see Figure 5). The first of the additional transistors (TXG or transfer gate transistor) is used to control the transfer of the signal charge from the photo diode into the floating diffusion capacitor. After the transfer is performed, the transistor opens up the connection between the two components, and the photo diode can be reset by the SG transistor and start a new exposure. The signal charge which is stored in the floating diffusion capacitor can be read out whenever needed. After the signal readout, the additional reset transistor (RST transistor) will reset the floating diffusion capacitor to prepare it for the next signal transfer from the photo diode. The two additional transistors per pixel permit the separation of the exposure period from the transfer period. Because of this, the Xensium-FT imager provides what is called global shutter behavior identical to all CCDs. The Xensium-FT imagers do not have any of the limitations of previous CMOS imagers with a rolling shutter, such as sensitivity to fast camera movements with short exposure time and sensitivity to short light flashes. In this aspect, the new Xensium-FT imagers are no different from any of the best CCD imagers used today.

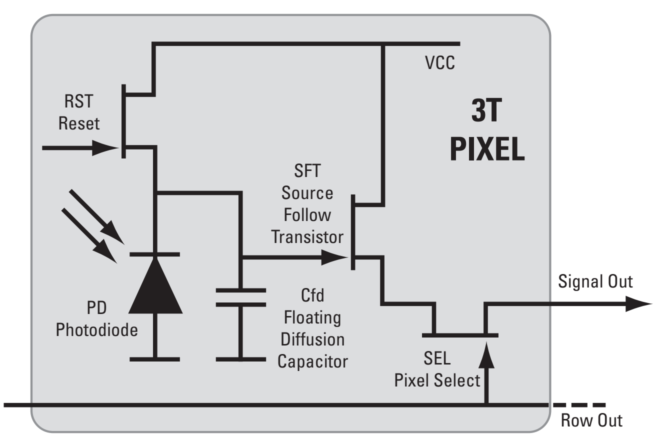


Figure 4 – CMOS imagers with 3T design of the pixels.

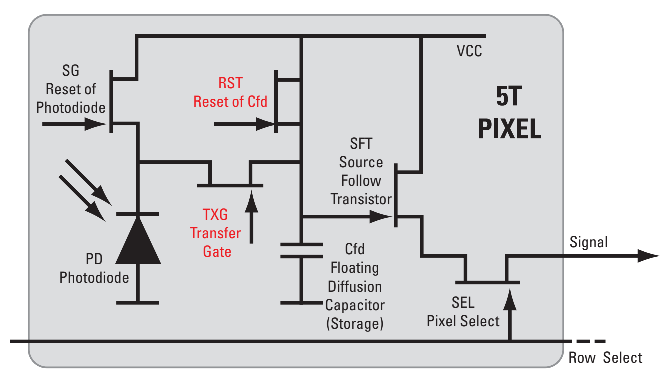


Figure 5 – Xensium-FT CMOS imagers are based on a 5T design of the pixels.

Why 5T Pixels Now?

If the two additional transistors per pixel are so important for the CMOS imagers, why has no one implemented them earlier? A historical look at chip manufacturing answers this question. A 2/3-inch HD imager with 1920x1080 progressive pixels has a pixel size of 5 µm x 5 µm. At the time of development for the original 3T Xensium™ imager, 0.25 µm masking technology was available. Using this masking technology, the three transistors consume around 44 percent of the total pixel size and only the remaining 56 percent of the pixel can be used to convert the incoming light to signal charge. This is described as the fill factor. With the two additional transistors needed for a 5T pixel, the fill factor would be around only 40 percent so the sensitivity with 5T pixels would have been an unacceptable 1/3 lower.

What's the difference in the new Xensium-FT imager? The new Xensium-FT imager, which has been developed more recently, uses a 0.18 µm mask and the transistors are made much smaller. Therefore, the 5T Xensium-FT imager offers a pixel a fill factor similar to the original 3T Xensium imager. These differences can be seen in the illustration in Figure 6.

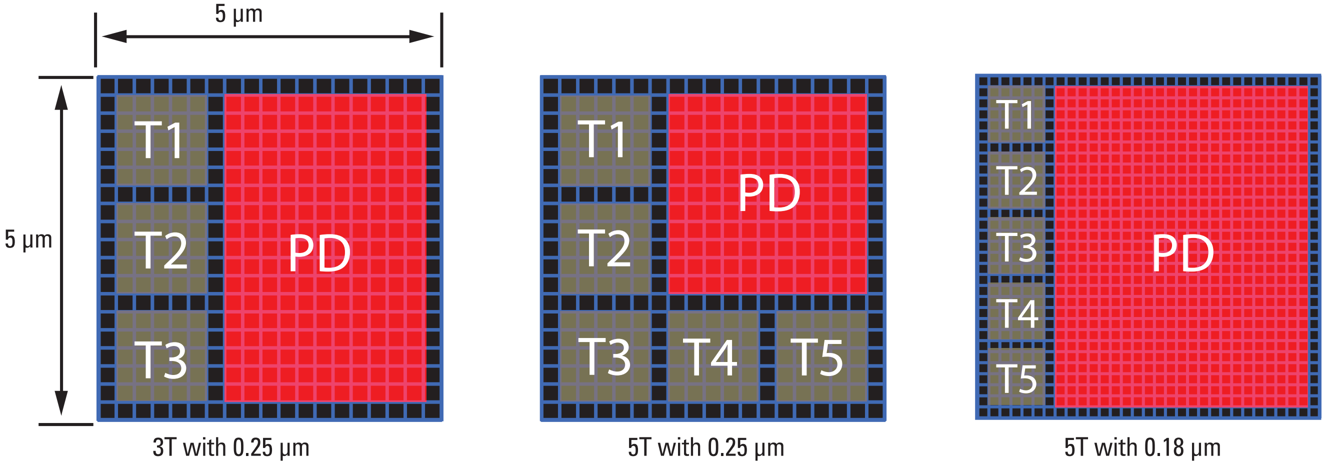


Figure 6 – Fill factor comparison between 3T pixels and 5T pixel with a 0.25 µm and 0.18 µm mask

Advantages in Progressive Formats and Sensitivity

What are the main advantages of today's CMOS imaging technology over CCDs? The answer begins with what initially seems to be a distinct disadvantage. For producing interlace formats, CCD imagers have always offered the advantage of being able to add the signal charge of two adjacent pixels to double the signal charge. As CMOS imagers convert the signal charge into a voltage inside the pixel, this additive property cannot exist. However, when addressing progressive formats, the problem shifts to CCD imagers, as they no longer have a combining charge, so a factor of two in sensitivity (one F stop) is lost. Additionally, the CCD needs a higher readout speed, where the CMOS is read out in parallel at lower speeds. Noise goes up with the square root of the bandwidth, so doubling this for progressive modes means losing an additional square root — or 3 dB — in noise performance, making a total of at least 9 dB. Therefore in interlace modes, CCD imagers offer more than double the sensitivity when compared to progressive formats. With CMOS, the sensitivity in interlace modes and in progressive modes is the same.

Until now, 1080i scanning modes have been used as the reference for sensitivity specifications, primarily because it showed the best figures for cameras which use CCD imagers. In the future however, progressive formats (1080p50 or 1080p59.94) will become much more important, especially as the high-resolution formats of the future (such as 4k, 8k and beyond) will only be implemented using progressive modes. When used in 1080i, the new Xensium-FT imagers offer at least equal, if not better sensitivity. However in progressive formats, Xensium-FT imagers offer a 6 dB improvement in sensitivity over any CCD camera on the market. This single feature alone makes it clear that end of life for the CCD technology in broadcast applications is upon us.

Why are the new Xensium-FT imagers more sensitive when compared to today's CCD imagers? It all starts with the quantum efficiency (QE) or incident photon to converted electron (IPCE) ratio. It is the percentage of photons hitting the device's photo reactive surface that produces charge carriers. QE is measured in electrons per photon or as a percentage which describes how many electrons are produced by photons hitting the surface. With current CCDs, this value is around 40 percent, whereas the new Xensium-FT imagers achieve a QE value of around 65 percent. In other words, much less light is needed to produce the same amount of signal charge. This increased sensitivity has now been combined with the introduction of the global shutter, which solves the single point that has been used as an argument against CMOS imaging technology — the rolling shutter. Improved sensitivity in progressive modes now offers a clear advantage for CMOS imaging technology over today's CCDs.

	Xensium-FT	IT CCD (typical)
1080i	F12	F11
1080p	F12	F8

Figure 7 – F-stop sensitivity of the Xensium-FT imager as compared to a typical IT CCD imager.

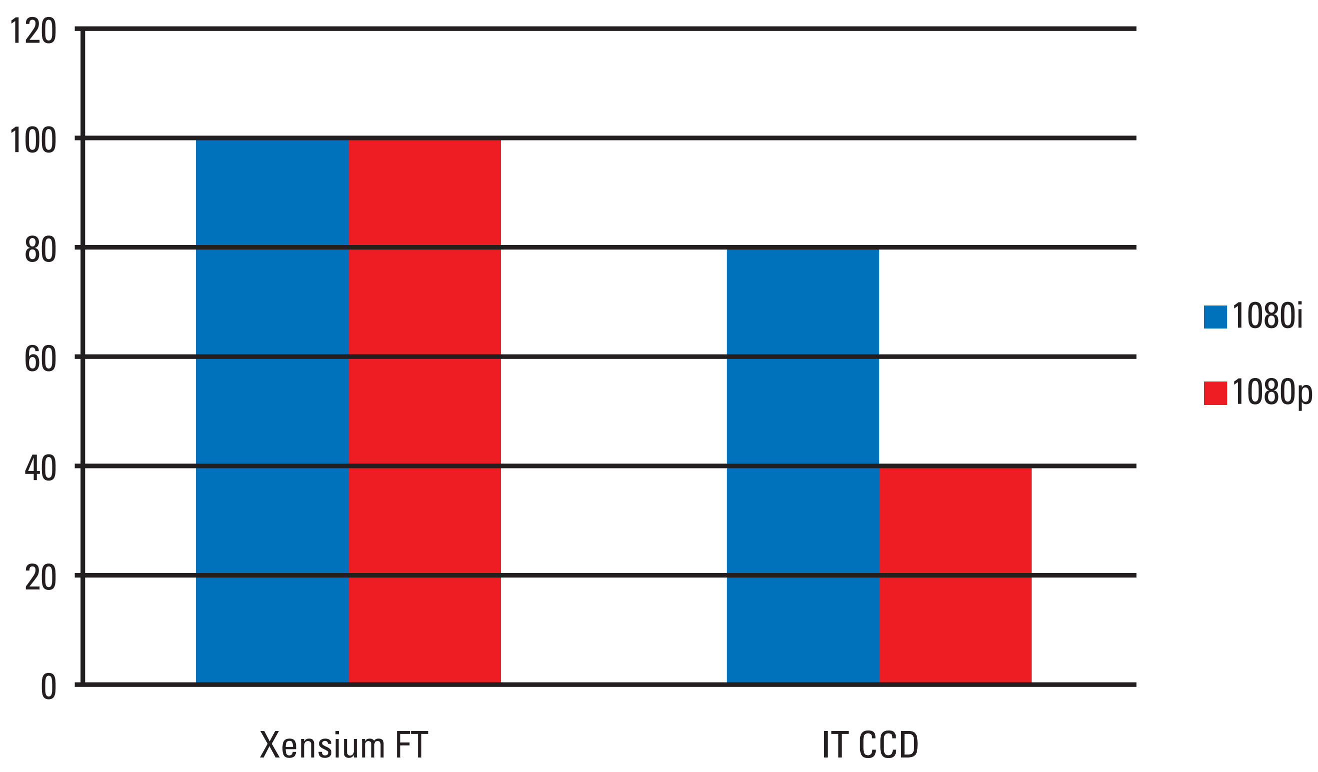


Figure 8 – Relative sensitivity of the Xensium-FT imager as compared to a typical IT CCD imager.

Resolution

Another aspect of imagers is resolution, and there is increasing discussion about 4K cameras. The Xensium-FT imager implementation compares favorably in this arena. Full 4K workflows are being evaluated for non-live applications such as cinema-style productions, several which have already been done. 4K is becoming an established cinema standard, and for the very large screens in cinemas the extended resolution of a true 4K RGB image offers a real advantage over 1920x1080 HD images. For a digital cinematography camera, the larger size imagers are not a disadvantage, and are even requested for artistic reasons to achieve the so-called "film look" of shallow depth of field. In addition, prime lenses or zoom lenses with a very limited zoom ratio are mainly used for theatrical productions, and they can be built with a reasonable size and weight, even when used with larger imagers. But the physical limitations on the zoom range caused by large imager sizes will not make these cameras an option for live sports or entertainment productions.

All of the available 4K cameras today use a single large-sized imager, whereas broadcast HD cameras use three 2/3-inch full HD imagers. On a camera with a single imager, the color information is generated by separating the light with colored filters in front of the pixels. In most cases a Bayer pattern filter is used to accomplish this, where 4,000 pixels per line will be divided into 2,000 green pixels at every line and 2,000 red pixels or 2,000 blue pixels at every second line. In other words, only one-half of the imager's resolution will be used for the green channel and only one quarter of the resolution will be used for red and blue channels. Under certain conditions, aliasing artifacts can be created. Using three 2/3-inch 4K imagers will result in a significant loss in sensitivity, as any single imager design would also do. Using three large-sized 4K imagers would require new lenses that would be prohibitively large in size and weight.

Xensium-FT imagers have the full 1920x1080 pixel resolution and they will always operate in a full progressive mode without any disadvantage in terms of sensitivity or noise. The separation of the three primary colors is accomplished with a prism beam splitter. Therefore, the full 1920x1080 resolution is available for all three channels — green, red and blue — without any compromise. Compared to the resolution of a single 4K imager camera that uses Bayer pattern color filters, a camera using three Xensium-FT imagers can offer resolution advantages in the color channels, especially with the emerging use of 1080p for production. This two megapixel progressive format significantly increases resolution over any 1.5G format and lends itself to being an excellent mastering format producing high-quality conversions to any format such as 4K, 1080i and 720p. Therefore, for live broadcast applications, using Xensium-FT imagers will provide the best balance between image resolution, sensitivity and signal-to-noise ratio.

Different Level of Complexity and Integration

A CCD front-end is much more complex and less integrated when compared to a CMOS front-end. It requires a very complex high voltage supply for the CCD output node and all the necessary readout pulses need to be generated externally. The output signals are analog which means they need to be preprocessed, amplified and converted into the digital domain with external A/D converters. All signal charges need to be shifted at a very high speed through the vertical and horizontal shift registers into a single output node where they are converted from a charge into a voltage. Because of that process, CCD front-ends have very high power consumption which translates into high temperatures and in many cases even requires active cooling.

In the Xensium-FT CMOS imagers, more advanced processing is built into the imager itself which reduces the complexity of the total camera system. The charge of each pixel is sampled individually inside the pixel and converted there to a voltage. The voltage of each pixel is addressed through a matrix and sent to the output. This process does not need much energy which translates into low power consumption, low heat and low noise. The result is better stability and reliability. An additional advantage is that the imager has a more elegant design and is simpler to implement, thus reducing the cost of ownership and improving performance.

In the following image (Figure 9), a comparison between a CCD front-end and a comparable FT CMOS front-end can be seen. Where the CCD front-end needs four large printed circuit boards (PCBs) on top of the three smaller PCBs which are directly mounted onto the CCD imagers, the FT CMOS front-end does not have any PCBs on top of the small ones mounted onto the three imagers. Additionally, the output signal at the CCD front-end is analog only and additional circuits are needed to amplify, preprocess and digitize the signals. With a CMOS front-end, all signals are digital straight out of the imagers.

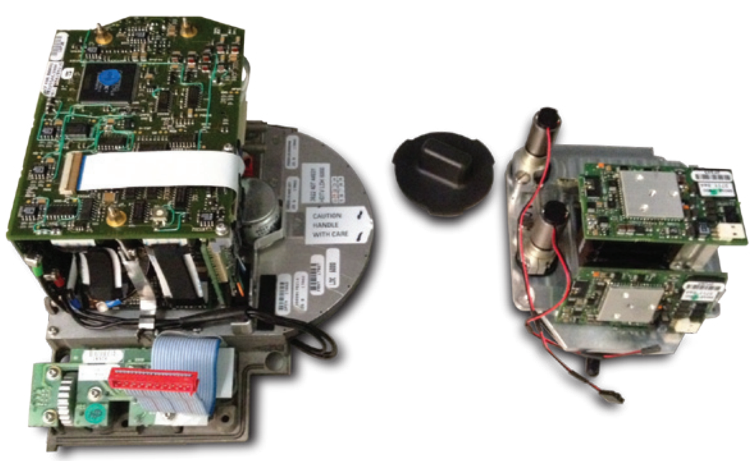


Figure 9 – Comparison of a CCD front-end (LDK 8000 Series on the left) and an FT CMOS front-end (LDX Series on the right).

Imaging Technology Summary

Although CCD imagers have been the standard for broadcast television productions for many years, they have reached the end of their growth path, with no new technological developments expected. The Xensium-FT imager is the first of a new generation of CMOS imagers which combines all the positive characteristics of CMOS imaging technology with the global shutter behavior of CCD technology. The real benefit is picture quality. Xensium-FT imagers produce a better quality picture compared to today's CCDs — even under the most difficult lighting conditions.

Xensium-FT imagers: A superior replacement for CCD technology!

Third-Generation Camera Transmission Solutions

There is a split between those users implementing triax and those using fiber. Triax has the advantage of being able to utilize existing cable infrastructures, and it's extremely robust with its easy-to-handle cables and connectors. Fiber offers larger headroom for extended bandwidth and format support, and much longer cable runs. However, in many cases, we want to be able to use both systems depending on the requirements of the production. To combine the strengths of both into a single transmission system, a completely new generation of camera transmission solutions had to be developed. The main components of this third-generation camera transmission system from Grass Valley were introduced at different international trade shows in 2011, with the final component — a 3G fiber to 3G triax converter box — being introduced in 2012.

Until Grass Valley 3G Transmission solutions became available, the choice for a camera transmission system was either triax or fiber. Once a choice was made, users were married to the decision for life, or confronted with serious restrictions when making conversions in the field. This resulted in making concessions with video quality and losing all transmission diagnostics. The Grass Valley 3G Transmission solution is different in one very notable way: it is a convergence of today's triax- and fiber-centric solutions into one. No more differences and limitations! The 3G Transmission topology has been crafted around the reality of broadcast life: very long pre-installed cable runs, multiple production formats and the need to produce images of the highest quality.

Today, with Grass Valley's 3G Transmission, outside broadcast (OB) companies can say "yes" to any kind of bid request or tender, without regard to camera transmission cable type. That's because 3G Transmission converges 3G triax and 3G fiber into a single transmission system. Grass Valley 3G Transmission solutions support all HD video formats — including 1080p50/60 — always offering exactly the same feature set fully independent of the cable type or even the combination of cable types used.

As previously stated, there are good reasons to opt for fiber cables and there are good reasons to opt for triax cables. Both have their particular strengths, but both also have limitations and the selection of cable type has to be selected on a production-by-production basis. Fiber transmission can be used for the longest cable runs and it offers the headroom for additional bandwidth requirements, such as super slo-mo camera systems. Triax transmission offers maximum reliability and robustness in the field. In addition, triax cables can be found at almost all prewired venues.

In many cases, triax and fiber are both needed in one production environment. For example, at a downhill ski race most camera positions can be reached either with a triax cable or a hybrid fiber cable. However some camera positions, typically those at the start which are far away from the OB van, can best be reached by (2X single mode) dark fiber cables. These are relatively cheap and in many cases they are already prewired at these locations. With the 3G Transmission Twin base station (with both triax and fiber connectivity) any combination of camera cables can be used directly from the base station: triax, dark fiber or hybrid fiber (with a converter box). This flexibility is achieved by having both transmission systems integrated into one base station without any limitations. That's different from other solutions currently available which use a conversion from one transmission system into the other, where limitations cannot be avoided. If the camera cable which is connected to the camera head should include power, a field converter somewhere near the camera is needed. At the converter, the two dark fiber cables will be converted into a hybrid fiber cable or to a triax cable depending on the transmission adapter used on the camera head. Figure 10 shows all of the different transmission possibilities when the camera head uses a 3G Transmission triax adapter. The example of the winter sports production described previously could use a combination of triax cameras (the first and second examples) for the camera positions located close to the OB van, and triax-to-dark fiber conversion (the third example from the top) for the camera positions which are located far away from the OB van.

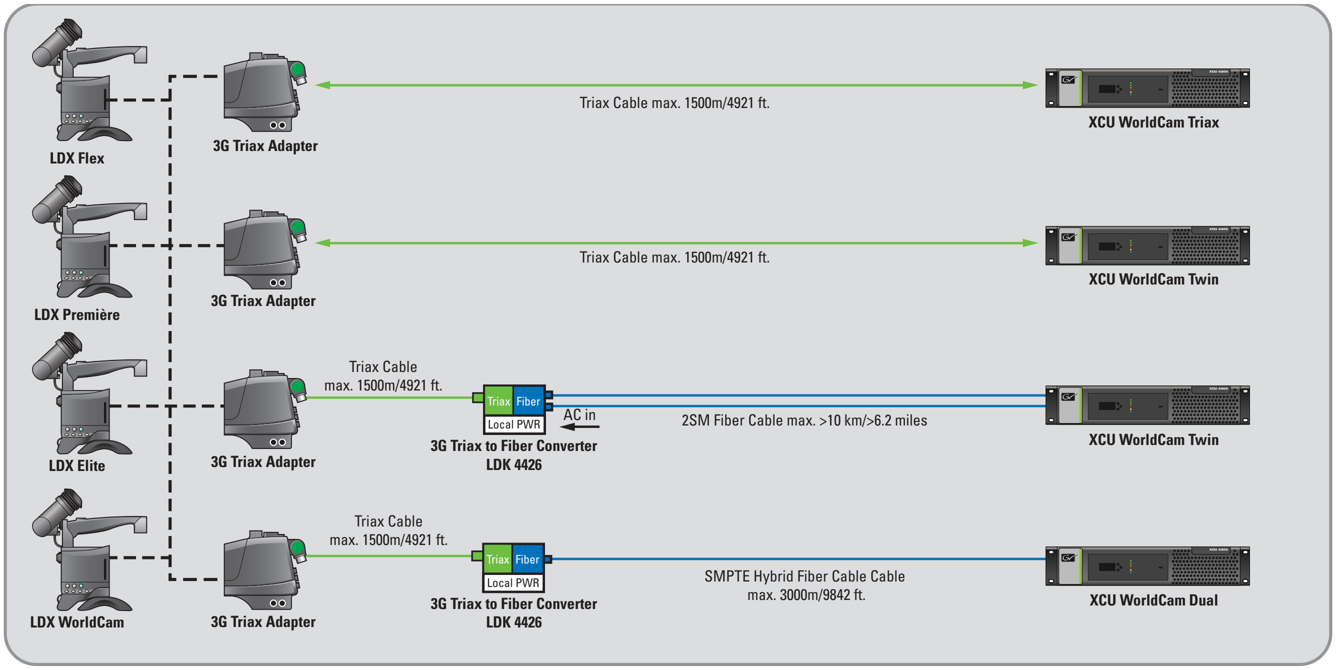


Figure 10 – 3G Transmission triax adapter transmission options.

Figure 11 shows the different transmission possibilities when the camera head uses a 3G Transmission fiber adapter. The example of the same winter sports production could use a combination of hybrid fiber cameras (the first, second or fourth examples from the top) for the camera positions close to the OB van, and hybrid fiber-to-dark fiber conversion (the third example from the top) for the camera positions which are located far away from the OB van. In the last example, a solution is shown where a fixed, preinstalled triax infrastructure is used in combination with a 3G Transmission fiber camera adapter.

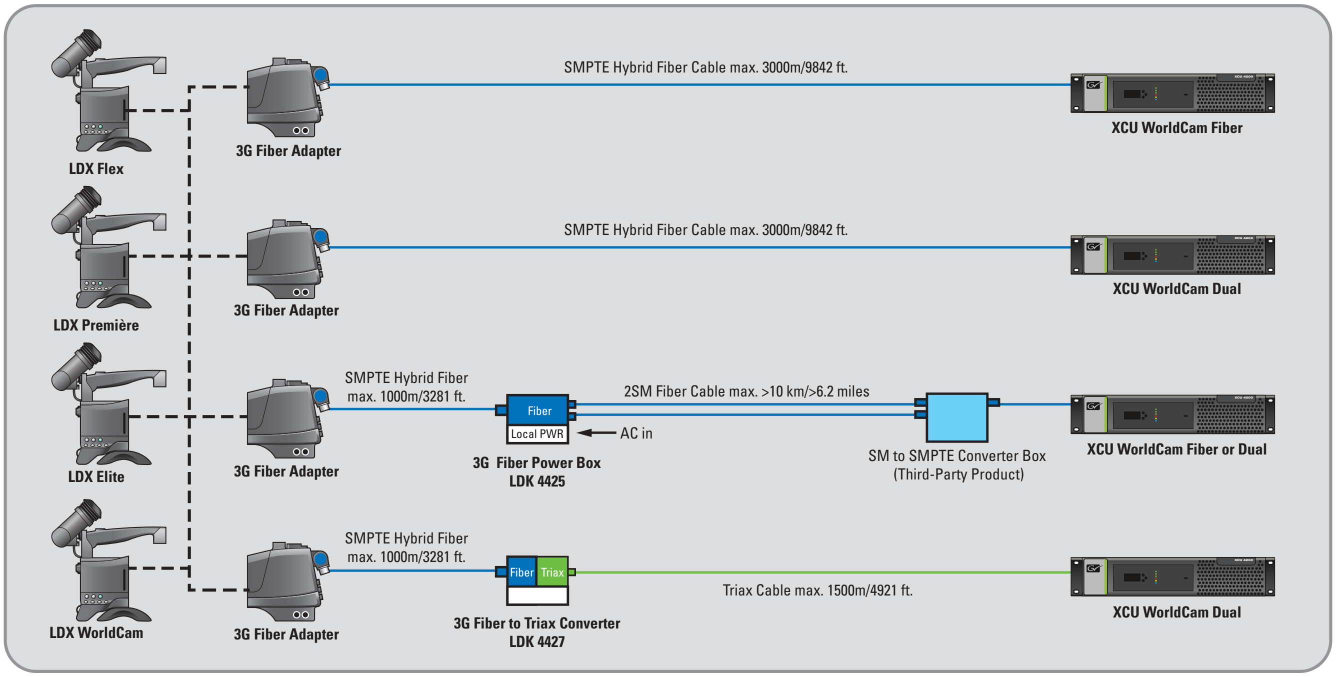


Figure 11 – 3G Transmission fiber adapter transmission options.

The flexibility of Grass Valley's 3G Transmission solution goes even further. In Figure 12, a transmission solution is documented where, by using a third-party CWDM system, up to four cameras of any combination of the LDX Series and LDK 8300 Live Super Slo-Mo cameras with fiber or triax transmission adapters can be multiplexed onto one single-mode fiber cable. With a minimum amount of fiber cables, the cameras can be extended by up to 50 km (31 miles) from their base stations while still offering full functionality and performance.

Integration into Riedel MediorNet has also become available. MediorNet is a real-time network for video, audio, data and communications to handle all baseband signals typically used in a broadcast production. The Riedel MN-GV-2, is a dedicated interface card for Grass Valley cameras. It permits the user to network Grass Valley 3G camera systems and base stations including LDK and LDX Series cameras via MediorNet. With camera integration into MediorNet, even the most demanding applications over distances of 50 km (31 miles) and more can be realized.

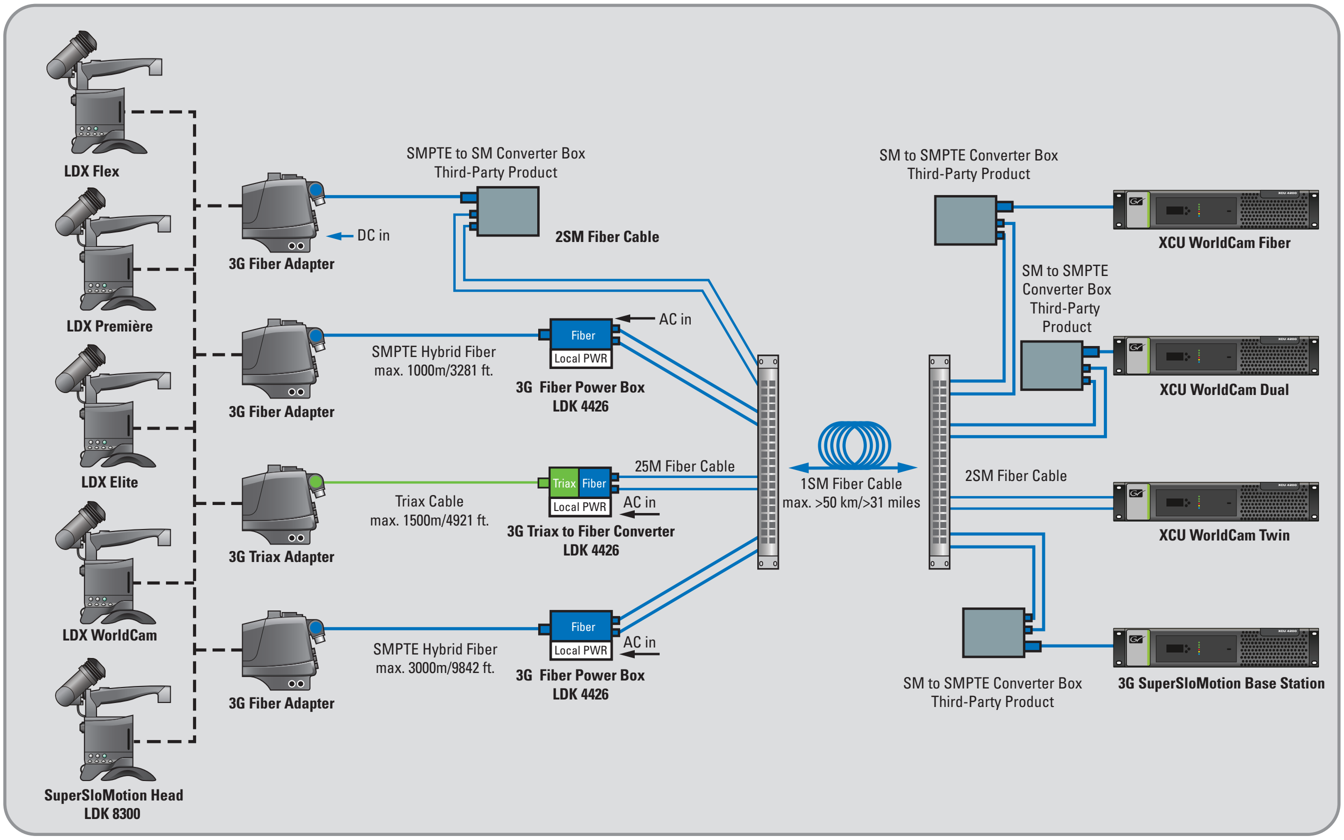


Figure 12 – 3G Transmission extended transmission options.

XCU Flexible Base Station Solution

New Trends and Implementation in Imaging Technology for the Future of Live Production

Grass Valley also offers the newest idea in broadcast camera base stations (CCUs). It is a revolutionary concept and a real game-changer for video production companies — such as OB truck operators — as it helps to minimize operational costs and streamlines the reconfiguration of OB trucks for each production with a unique cradle concept.

The XCU WorldCam replaces the current range of LDK 3G Transmission base stations and offers the same functionality and performance. XCU provides a unique “cradle” concept which allows for easy “slide-in” and “slide-out” of the XCU into and out of a pre-mounted XCU cradle.

Empty XCU cradles can be installed in an OB truck or fixed studio installation. All cables (except power and camera triax/fiber) are connected to the XCU cradle allowing for the XCU to be easily relocated without disconnecting any cables.

An EEPROM built into the XCU cradle remembers the previous settings and can automatically re-configure itself to the requirements of the production environment. With the XCU WorldCam, Grass Valley creates maximum business flexibility and operational excellence.

The primary benefits are minimizing the time spent to reconfigure the OB truck, and minimizing cabling mistakes — as cradles remain cabled for easy exchange of XCUs between different OB trucks. Quick set-up times can be achieved due to pre-settings in the XCU cradle.

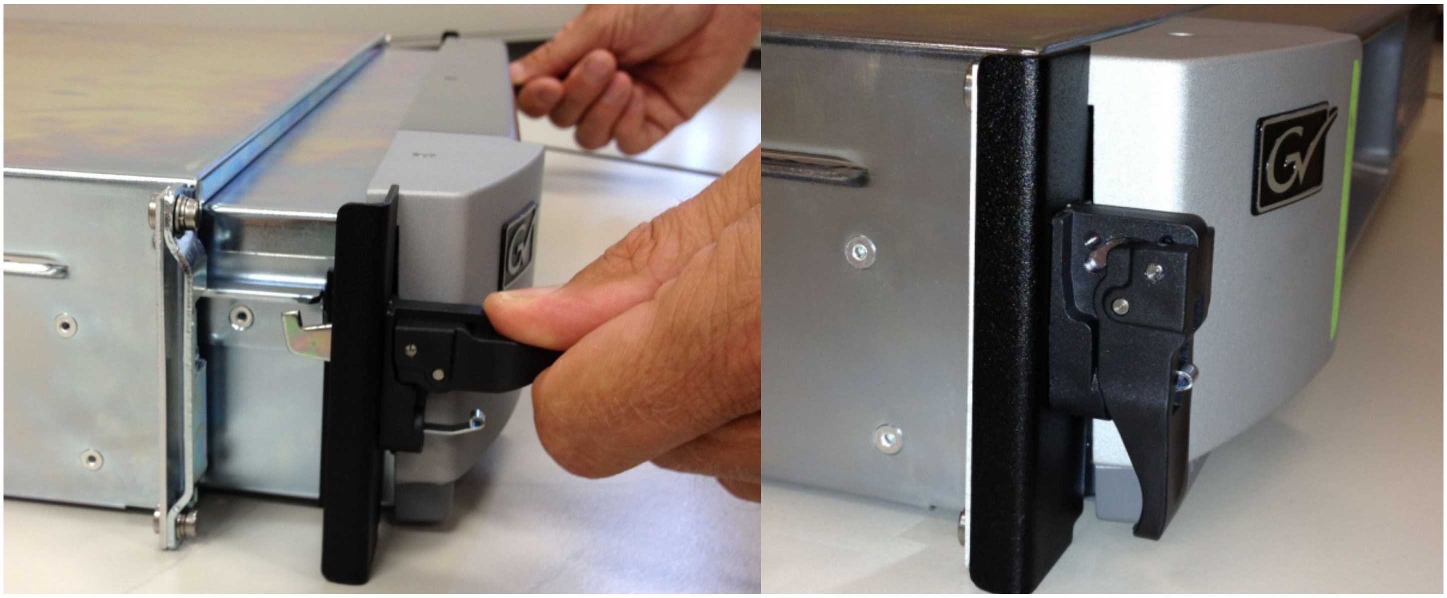


Figure 13 – The XCU base station and cradle. An EEPROM built into the XCU cradle will remember the previous settings and can automatically re-configure itself to the requirements of the production environment.

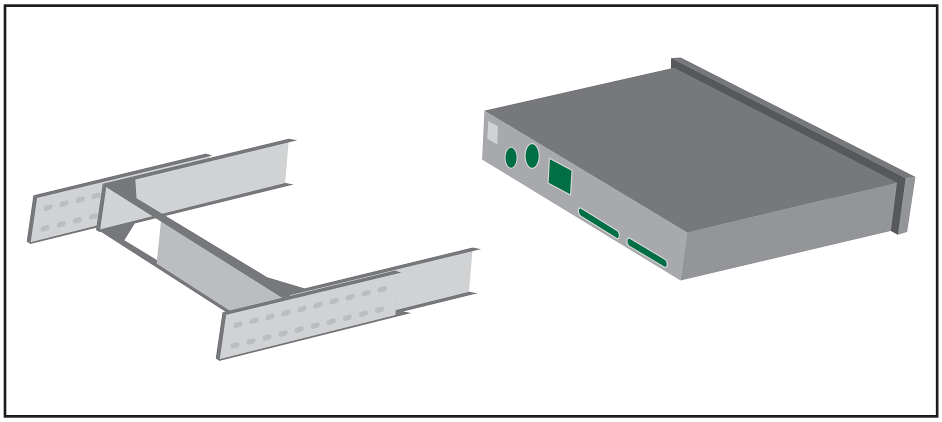


Figure 14 – The XCU concept allows for easily swapping base stations between OB trucks and fixed studios.

Camera Control Solution: Connect Gateway

There is one more important point to consider, especially with long distance operations and/or the use of multiple cable combinations. It is the use of open standards IT interfaces and protocols for the camera control system and full transmission diagnostics. With Connect Gateway, Grass Valley offers a unique solution for local and remote diagnostics of all camera systems in a production. With an off-the-shelf Wi-Fi extender, remote monitoring from a tablet or smartphone is possible. Connect Gateway also provides digital tally control from all current Grass Valley production switchers and allows for third-party control integration into the Ethernet-based C2IP camera control network.

For remote camera applications over ultra-long distance, the Ethernet-based control solution with Connect Gateway offers a unique way of seamless camera control integration. Over a standard 10Base-T/100Base-T connection between two or even more locations, full control of up to 99 camera systems can be achieved with all previously mentioned features. With Connect Gateway, the camera control system no longer needs to be a closed island inside the production environment, but can be a fully integrated part of the total control solution.

A facility control system can now memorize and recall all camera-related settings in the same way that was previously done for the other production equipment. This new level of integration will allow users to reduce set-up time and to remove one potential source of errors.

Figure 15 – A diagnostics screen from Connect Gateway

The LDX Series of Cameras: A Software Upgradable Camera Platform

The LDX Series of software upgradable cameras is Grass Valley's answer to the increasing demands of HD live and studio-based production. With four levels — LDX Flex, LDX Première, LDX Elite and LDX WorldCam — the LDX Series offers unmatched technological sophistication that delivers higher quality images, greater control over acquisition and increased creativity.

The LDX Series was designed with both users and viewers in mind. Based on next-generation Xensium-FT imagers, LDX Series cameras provide high sensitivity in all supported video formats. In combination with an improved digital noise reduction system and a new texture preservation processing system, it makes 1080p acquisition — even under low light conditions — effortless. An improved CLASS feature now supports the digital chromatic lens error correction in horizontal and vertical direction (horizontally only for the LDX Flex). The dynamic contour equalizer and the advanced secondary color corrector permit users to adjust the camera for different production requirements. Smart coupling between functions and a streamlined menu structure support ease of use and help achieve higher quality artistic imagery. Ergonomic buttons, control knob layout and an adjustable shoulder pad ensure superb operability and comfort for users.

Supporting improved production efficiency, each LDX Series camera includes several features that increase communication between the operator and the production center. With unique features such as ArtTouch, PickMe, Endless Returns and Scene Direct, camera operators can easily control creative aspects and attract the director's attention to a particularly compelling image.

ArtTouch is a smart coupling between functions and the streamlined menu structure. With ArtTouch, certain settings that in many situations are interrelated are linked together so the setting(s) can be changed as a single group. This is similar to some automated settings on digital still cameras.

With PickMe, a camera operator has the ability to send metadata using a trigger from their camera that initiates a set of actions, from getting the director's attention visually (instead of by headphones) to initiating a set or pre-determined actions, such as switching a live web-feed to their camera. In this case, the technology can be used to create a secondary online highlight or home team feed for the web, complete with revenue generating possibilities.

Endless Returns gives the camera operator router control of the signals being sent to the camera's return input of the camera's base station. The number of different signals which can be selected is limited only be the size of the external router.

Scene Direct offers the possibility to do some basic camera control, such as scene file recall for preview and review, from any of the current Grass Valley video production switchers.

Through Connect Gateway it is possible to remotely provide the production center full control over camera functions. The LDX Series is a true camera for the future because it has the ability to grow as imaging requirements change. A unique software structure provides the opportunity to upgrade through the LDX Series, giving each camera incredible flexibility and making the LDX Series an exceptional investment. The LDX Series camera heads are fully compatible with all Grass Valley 3G Transmission solutions.

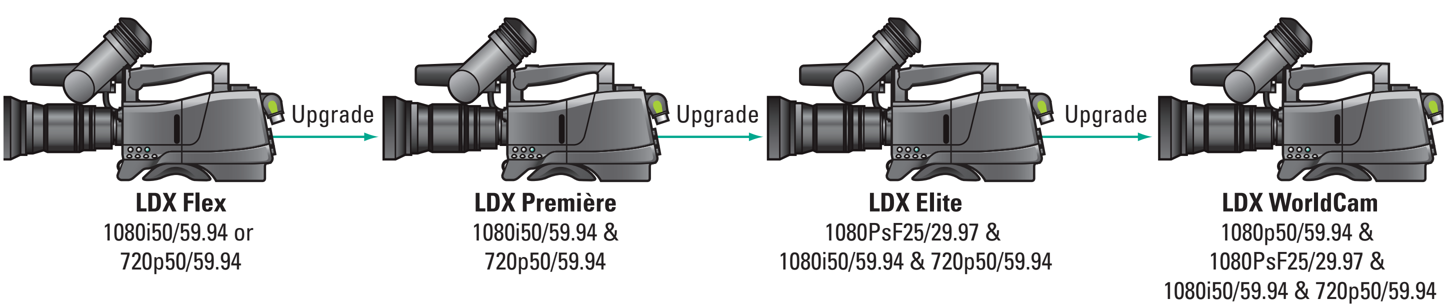


Figure 16 – LDX Series camera heads offer an upgrade path.

Conclusion

Although CCD imagers have been the standard for broadcast television production for many years, they have reached the end of their lifecycle. The Xensium-FT imager is the first of a new generation of 2/3-inch CMOS imagers which combines all of the positive characteristics of CMOS imaging technology with the global shutter behavior of CCD technology. The real benefit is picture quality. Xensium-FT imagers produce a better quality picture compared to today's CCDs — even under the most difficult lighting conditions. They are a superior replacement for CCD technology!

The increased demands for flexibility, and the basis for all developments going forward in cabling infrastructure, in combination with the request for higher bandwidth production formats make Grass Valley 3G Transmission solutions highly desirable. The 3G Transmission series has been developed with the future in mind and offers maximum flexibility while helping to minimize operational costs. This solution is the world's first and only transmission system that supports all HD video formats: 720p, 1080i and 1080p, over any kind of camera cable being used in broadcast applications. 3G Transmission solutions from Grass Valley offer the ultimate performance, feature set and flexibility today and for the future.

The very powerful Grass Valley C2IP camera control system offers Ethernet-based TCP/IP control of up to 99 digital Grass Valley cameras. Connect Gateway acts as a bridge between the private C2IP camera control network and a public Ethernet-based network. It provides tighter integration and control between Grass Valley products and opens up the camera control system in ways that have never before been possible. In addition, Connect Gateway offers very strong diagnostic features including remote monitoring.

The LDX Series of software upgradable cameras is Grass Valley's answer to the increasing demands of HD live and studio-based production. It offers a new level of image performance using 2/3-inch Xensium-FT CMOS imagers in combination with the latest improvements in digital signal processing.

With many new operational features and improvements as well as integration with unique 3G Transmission solutions and the C2IP camera control system, Grass Valley now offers:

The most advanced camera solution in the world!

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