PHYTEC Messtechnik GmbH

Application Note

How to use phyCAM camera modules with phyCORE-i.MX6 SBC

Revision History

Version	Changes	Author	Date
A0	Initial Release	H. Fendrich	08.08.2018
A1	added VM-016 camera modul	H. Fendrich	09.07.2019

Content

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1 Overview

The i.MX6 Microcontroller supported more then 1 camera interface (see figure 1).

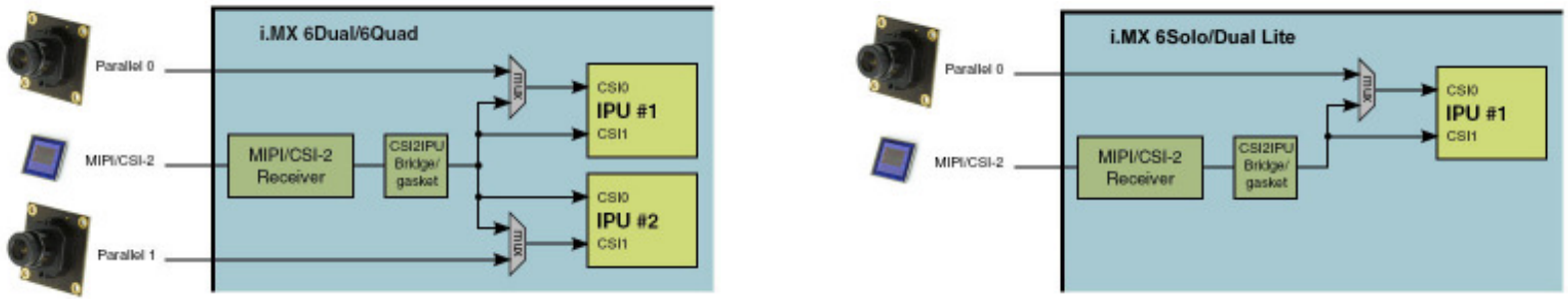

figure 1: Block Diagram Camera Interfaces of i.MX6 Controller (Quad / Dual) and i.MX6 Controller (Solo / Dual Lite)

On the phyCORE-i.MX6 the CSI0/IPU#1 camera path go out as parallel signal. (see figure 2)

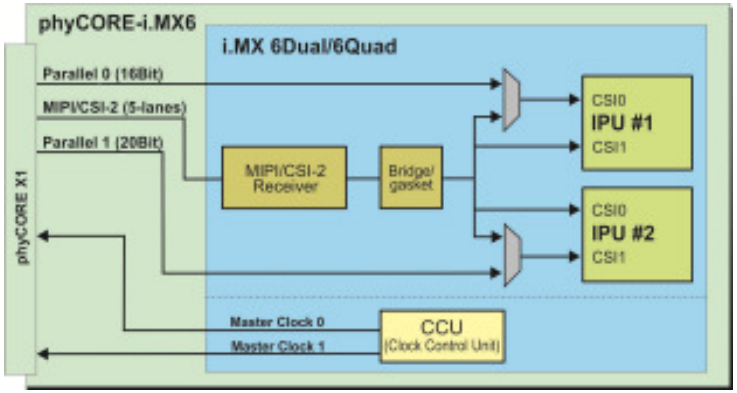

figure 2: Use of Camera_0 (CSI0 of IPU#1) and Camera_1 (CSI1 of IPU#2)

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On the PHYTEC or customer carrier boards can the interfaces are led out as phyCAM-P (or raw-parallel) see figure 3 and/or phyCAM-S+ see figure 3 or MIPI/CSI 2 interface. For more information to phyCAM-P/S+ see manual L-748.

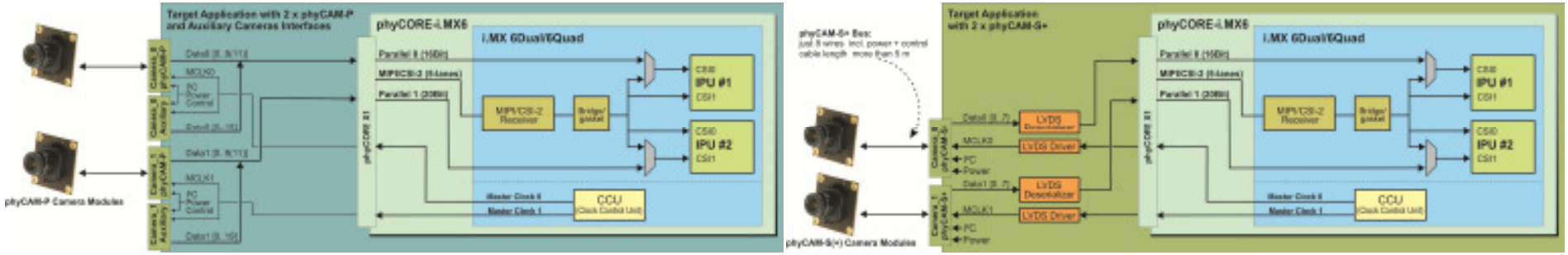

figure 3: Block Diagram of an phyCAM-P solution and an phyCAM-S (+) solution with phyCORE-i.MX6 (Quad / Dual) SBC

On the phyBOARD-Nunki baseboard are all camera interfaces led out as as phyCAM-P (or raw-parallel) as phyCAM-S+ and as MIPI/CSI-2 interfaces-I (see figure 4). Here you can connect different phyCAM-P or/and phyCAM-S(+) or phyCAM-M camera modules. See the phyCAM-P/-S manual L-748 for more information.

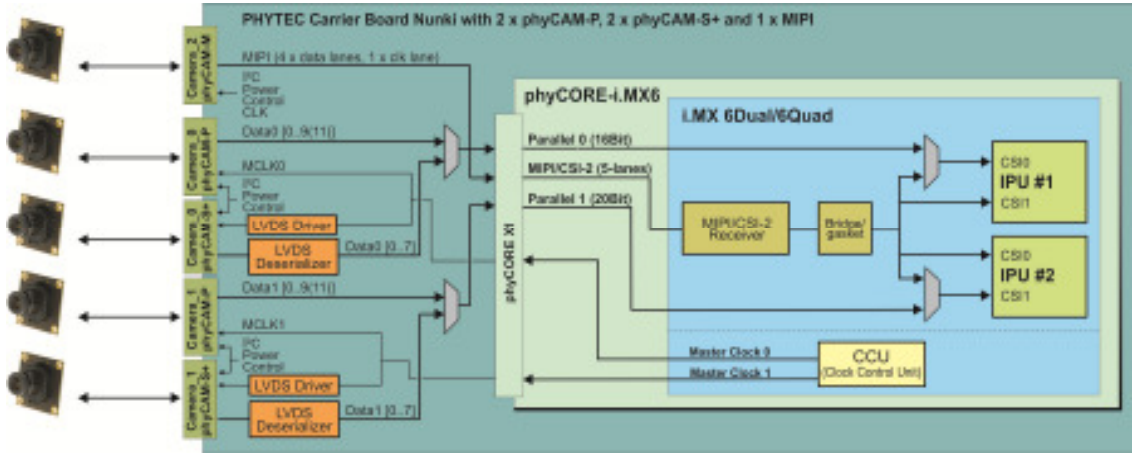

figure 4: Block Diagram of phyCAM Camera Interfaces of phyCORE-i.MX6 (Quad / Dual) and the go out on the phyBOARD-Nunki-i.MX6 - SBC

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The BSP shipped with the Kit includes already the software drivers for the supported phyCAM camera modules. The drivers are compatible with v4l2. Also GStreamer scripts are included for the evaluation of the camera modules. If you need the camera interface to connecting your own camera modul, please use pin header the phyFLEX-i.MX6 Modul.

Note:

The phyBOARD-Nunki features the CSI interface for phyCAM-P and phyCAM-S(+) camera modules and the MIPI Interface for phyCAM-M camera modules. Please find more information about the camera support in the path: …\Documentation\...

Note that the parallel and serial input of each channel is fed into the same input of the i.MX-6.
Thus, for each input either the parallel or the serial interface or the MIPI interface can be used, but not all at the same time.
The selection between phyCAM-P, phyCAM-S(+) and phyCAM-M is done by a software parameter in the config file (see below).
If a channel is configured as parallel input, this also automatically disables the LVDS deserializer on the Nunki board for this channel.

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2 Camera Connectors on the NUNKI - Carrier Boards

The development kits for the phyBOARD-NUNKI-i.MX6 contain:
- one carrier board (NUNKI)
- one phyCORE-i.MX6 modul SOM

The carrier board connects to the phyCORE-connector, with the phyCORE-i.MX6 modul.

On the base board NUNKI (PBA-C-11-001) we convert the parallel Camera_0 and Camera_1 interface in:
- phyCAM-S+ camera interface standard (support on connector X1/X2)
- phyCAM-P camera interface standard (support on connector X6/X7)

Or led out as phyCAM-M interface standard (support on connector X32) **Note: As of PCB Version PL1489.3, the phyCAM-MI interface has been changed and is located on the back side of connector X35.**

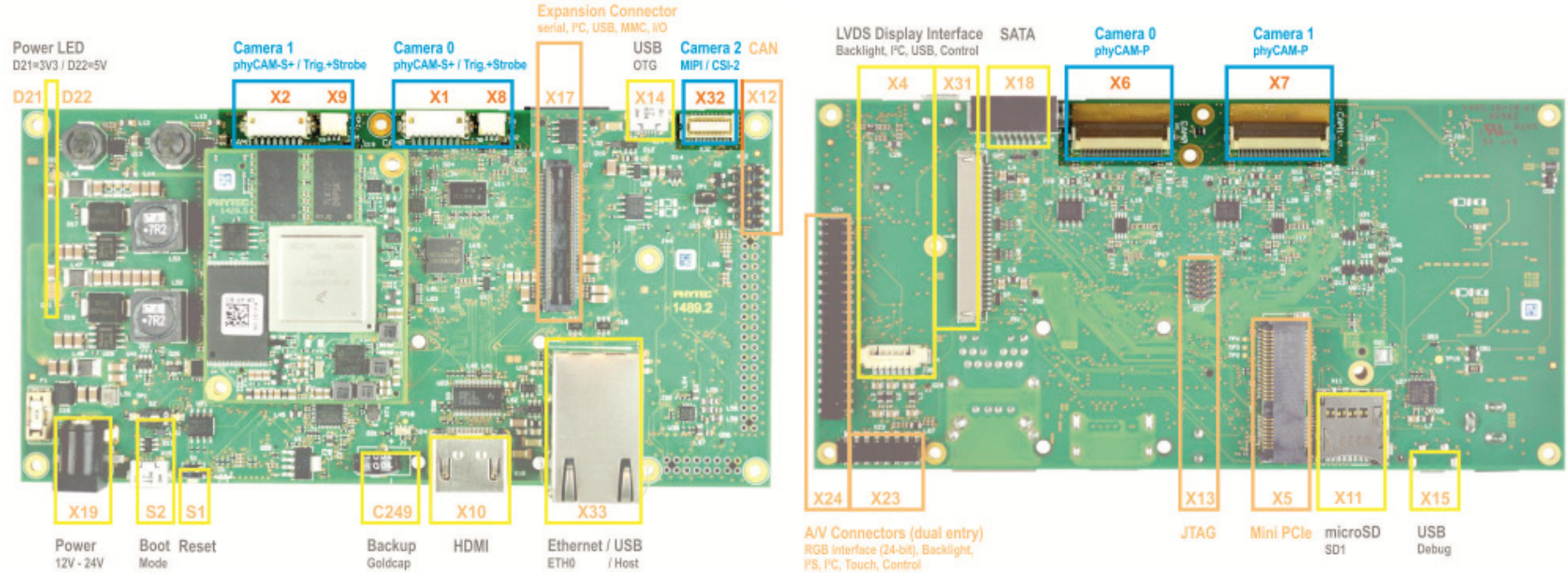

figure 5: Camera Interfaces on phyBOARD-NUNKI up PCB Version PL1489.2 for the phyCORE-i.MX6 SOM

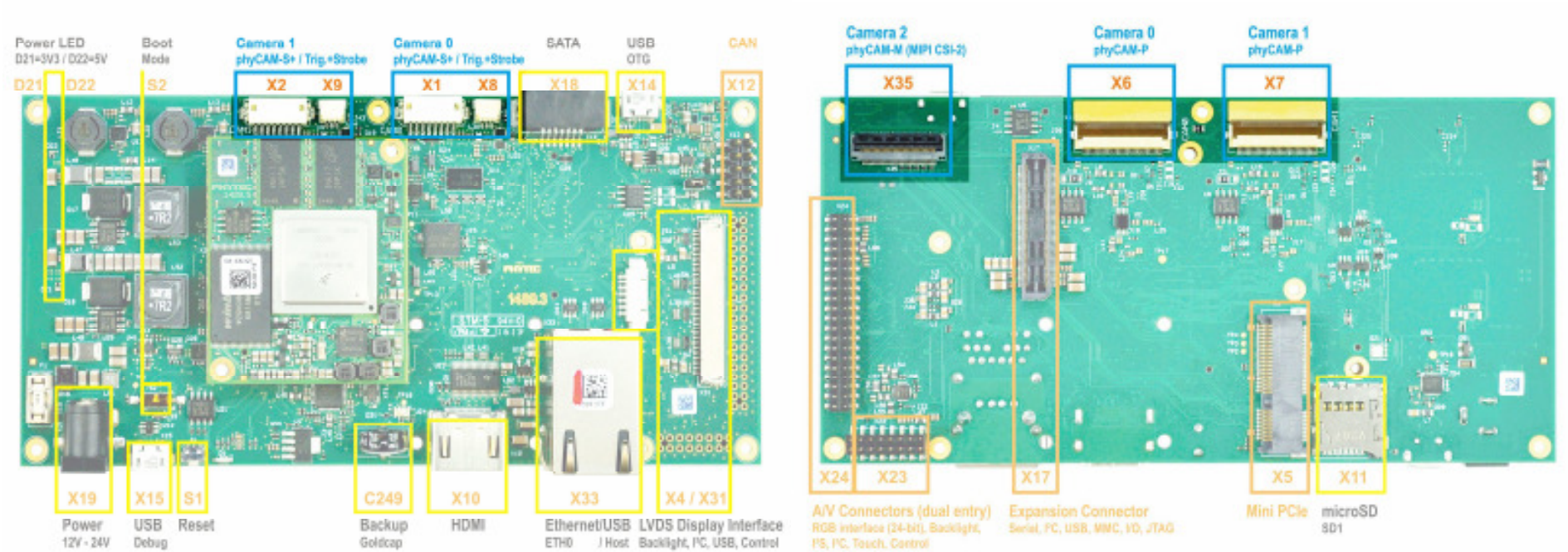

figure 6: Camera Interfaces on phyBOARD-NUNKI from PCB Version PL1489.3 for the phyCORE-i.MX6 SOM

3 Change the cameras or camera parameters (YOCTO Linux PD18.1.0 and higher)

The cameras and the camera interface supported as a sub-devices. To configure is used the multimedia framework "media control".
The conversion of the formerly from PHYTEC supported camera driver, camera interface and the IPU and VPU support is not yet complete.

For more information see on FTP:
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Nunki-i.MX6_linux_PD18.1.x/

The configuration in the config-expansions file must match with the camera models that are connected to the camera interfaces.
Note that model, interface type and I²C-addresses must be set correctly. Otherwise the camera(s) are not working.
Please check, if the correct camera model is set in the config file. If not, please follow the steps below to set the appropriate configuration.

Changing the setting of the config-expansions parameters

To change the config-file (config-expansions), use the Barebox environment: Use a terminal program e.g. "Putty".

- 'cd env' <enter>
- 'edit config-expansions' <enter>

The following settings in config-expansions - file are necessary:
of_camera_selection -p <csi_port> -b <csiX_cam_bus_type> -a <csiX_cam_i2c_address> <cam_type>

- csi_port = [0,1]
- csix_cam_bus_type = [phyCAM-P, phyCAM-S+] (Note: phyCAM-M not yet supported)
- csix_cam_i2c_address = [0x41-0x5D] depend of camera type/settings
- csix_cam_type = [VM-006, VM-008, VM-009, VM-010-BW, VM-010-COL, VM-011-BW, VM-011-COL]

Example: VM-010-BW-LVDS with i2C-address 0x48 on CSI0 (Camera_0) port
[of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-010-BW]

The parameters for the phyCAM – modules are shown in the table below (see next page).

After changing the settings with the editor:

- close the editor (CTRL D)
- type 'saveenv' <enter> to save
- restart PHYTEC module

After login, change into the directory: \gstreamer_examples\..
cd gstreamer_examples <ENTER>.

Now you can start working with the GStreamer demo-scripts. Detailed information about the GStreamer examples can be found in the phyCAM-Manual L-748.

Hardware Configuration		Bootarg Parameters				Bootarg settings for default I²C-address (default jumper on camera and boards)
phyCAM camera model (part number)	connected to	csi_port	csi[X]_cam_bus_type	csi[X]_cam_type	csi[X]_cam_i2c_address	
VM-006-BW (-M12 / -H) (not yet supported)	X6 on Nunki board	0	phyCAM-P	VM-006	0x5D, 0x41	of_camera_selection -p 0 -b phyCAM-P -a 0x5D VM-006
	X7 on Nunki board	1	phyCAM-P	VM-006	0x5D, 0x41	of_camera_selection -p 1 -b phyCAM-P -a 0x5D VM-006
VM-006-BW-LVDS (-M12 / -H) (not yet supported)	X1 on Nunki board	0	phyCAM-S+	VM-006	0x5D, 0x41	of_camera_selection -p 0 -b phyCAM-S+ -a 0x5D VM-006
	X2 on Nunki board	1	phyCAM-S+	VM-006	0x5D, 0x41	of_camera_selection -p 1 -b phyCAM-S+ -a 0x5D VM-006
VM-008 (not yet supported)	X6 on Nunki board	0	phyCAM-P	VM-008	0x44, 0x45	of_camera_selection -p 0 -b phyCAM-P -a 0x45 VM-008
	X7 on Nunki board	1	phyCAM-P	VM-008	0x44, 0x45	of_camera_selection -p 1 -b phyCAM-P -a 0x45 VM-008
	X1 on Nunki board	0	phyCAM-S+	VM-008	0x44, 0x45	of_camera_selection -p 0 -b phyCAM-S+ -a 0x45 VM-008
	X2 on Nunki board	1	phyCAM-S+	VM-008	0x44, 0x45	of_camera_selection -p 1 -b phyCAM-S+ -a 0x45 VM-008
VM-009 (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-009	0x48, 0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-009
	X7 on Nunki board	1	phyCAM-P	VM-009	0x48, 0x5D	of_camera_selection -p 1 -b phyCAM-P -a 0x5D VM-009
VM-009-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-009	0x48, 0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-009
	X2 on Nunki board	1	phyCAM-S+	VM-009	0x48, 0x5D	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-009
VM-010-BW (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-010-BW
	X7 on Nunki board	1	phyCAM-P	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-P -a 0x4C VM-010-BW
VM-010-BW-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-010-BW
	X2 on Nunki board	1	phyCAM-S+	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-010-BW
VM-010-COL (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-010-COL
	X7 on Nunki board	1	phyCAM-P	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-P -a 0x4C VM-010-COL
VM-010-COL-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-010-COL
	X2 on Nunki board	1	phyCAM-S+	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-010-COL
VM-011-BW (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-011-BW	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-011-BW
	X7 on Nunki board	1	phyCAM-P	VM-011-BW	0x48,0x5D	of_camera_selection -p 1 -b phyCAM-P -a 0x5D VM-011-BW
VM-011-BW-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-011-BW	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-011-BW
	X2 on Nunki board	1	phyCAM-S+	VM-011-BW	0x48,0x5D	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-011-BW
VM-011-COL (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-011-COL	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-011-COL

	X7 on Nunki board	1	phyCAM-P	VM-011-COL	0x48,0x5D	of_camera_selection -p 1 -b phyCAM-P -a 0x5D VM-011-COL
VM-011-COL-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-011-COL	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-011-COL
	X2 on Nunki board	1	phyCAM-S+	VM-011-COL	0x48,0x5D	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-011-COL
VM-012-BW (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-012-BW
	X7 on Nunki board	1	phyCAM-P	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-P -a 0x4C VM-012-BW
VM-012-BW-LVDS (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-012-BW
	X2 on Nunki board	1	phyCAM-S+	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-012-BW
VM-012-COL (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-012-COL
	X7 on Nunki board	1	phyCAM-P	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-P -a 0x4C VM-012-COL
VM-012-COL-LVDS (-M12/-H)	X1 on Nunki board	0	phyCAM-S+	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-012-COL
	X2 on Nunki board	1	phyCAM-S+	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-012-COL
VM-050 (-021-0 / -050-0)	X6 on Nunki board	0	phyCAM-P	VM-050	0x4A, 0x4E, 0x5A, 0x5E	of_camera_selection -p 0 -b phyCAM-P -a 0x4A VM-050
	X7 on Nunki board	1	phyCAM-P	VM-050	0x4A, 0x4E, 0x5A, 0x5E	of_camera_selection -p 1 -b phyCAM-P -a 0x4E VM-050
VM-051 (-050-0 / -105-0)	X6 on Nunki board	0	phyCAM-P	VM-050	0x4A, 0x4E, 0x5A, 0x5E	of_camera_selection -p 0 -b phyCAM-P -a 0x4A VM-050
	X7 on Nunki board	1	phyCAM-P	VM-050	0x4A, 0x4E, 0x5A, 0x5E	of_camera_selection -p 1 -b phyCAM-P -a 0x4E VM-050

Notes:

- csi[X]_cam address must be identical to the I²C-address of the corresponding camera. I²C addresses of the camera are set by hardware configuration (jumper setting on the camera and / or on the baseboard / mapper board. Please refer to the phyCAM-manual L-748 and the hardware manual of the kit.
- If two cameras are used at the same time, csi[X]_cam address must be different for CAM0 and CAM1.

3.1 Change the cameras or camera parameters for VM-016 camera series (YOCTO Linux PD18.1.1 and higher)

Before you can use the PD18.1.1 with a VM-016 camera , you have to be generate an new image or use the ready SD-Card image for the Nunki board. See more on ftp: ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Nunki-i.MX6_linux_PD18.1.x/Software/

For the VM-016 cameras with phyCAM-P and phyCAM-S+ interface are the syntax equal as in chapter 3.
For the VM-016 cameras with phyCAM-M interface is a new parameter (-A) necessary and the parameter (-p) is no longer necessary.

- dt_node = [0x10, 0x18] devicetree node, Activated the mipi-blocks to configure with media-ctl.

Hardware Configuration		Bootarg Parameters				Bootarg settings for default I²C-address (default jumper on camera and boards)
phyCAM camera model (part number)	**connected to**	**csi_port**	**csi[X]_cam_bus_type**	**csi[X]_cam_type**	**csi[X]_cam_i2c_address**	
VM-016-BW-P (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-P -a 0x10 VM-016
	X7 on Nunki board	1	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 1 -b phyCAM-P -a 0x18 VM-016
VM-016-BW-S (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-S+ -a 0x10 VM-016
	X2 on Nunki board	1	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 1 -b phyCAM-S+ -a 0x10 VM-016
VM-016-COL-P (-M12 / -H)	X6 on Nunki board	0	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-P -a 0x10 VM-016
	X7 on Nunki board	1	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 1 -b phyCAM-P -a 0x18 VM-016
VM-016-COL-S (-M12 / -H)	X1 on Nunki board	0	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-S+ -a 0x10 VM-016
	X2 on Nunki board	1	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 1 -b phyCAM-S+ -a 0x10 VM-016
phyCAM camera model (part number)	**connected to**	**dt_node**	**csi[X]_cam_bus_type**	**csi[X]_cam_type**	**csi[X]_cam_i2c_address**	**Bootarg settings for default I²C-address (default jumper on camera and boards)**
VM-016-BW-M (-M12 / -H)	X35 on Nunki board	0x10, 0x18	phyCAM-M	VM-016	0x10, 0x18	of_camera_selection -b phyCAM-M -a 0x10 VM-016 –A 0x10
VM-016-COL-M (-M12 / -H)	X35 on Nunki board	0x10, 0x18	phyCAM-M	VM-016	0x10, 0x18	of_camera_selection -b phyCAM-M -a 0x10 VM-016 –A 0x10

4 GStreamer function

After login, change into the directory: \gstreamer_examples\..
cd gstreamer_examples <ENTER>.

At the first start disable the QT-Demo. Start the script “remove_qt_demo.sh”.

Now you can start working with the GStreamer demo-scripts.
Information’s about the GStreamer examples are in the notes in the scripts and can be found in the phyCAM-Manual L-748.

Up the kernel version 3.19 we use the media-device structure. So all camera/video components get a separate "/dev/video[x]" or "dev/v4l-subdev[x]" device.
Show the mapping with type: "media-ctl –p". The capabilities are showed if you type: "v4l2-ctl -d [device] --all" e.g. "v4l2-ctl -d /dev/v4l-subdev5 --all".

5 GStreamer function for improved Tearing reduction

Tearing is a visual artifact in video display where the display image shows information from two or more frames in a single screen draw.
It appears as a horizontal border or line. The image part beyond the line seems to be shifted horizontally when the image content or the camera is moved.
The tearing line(s) usually move(s) vertically across the image.
The artifact occurs when the camera framerate differs from the display frame or the camera readout cycle is not in sync with the display's refresh.
Definition and background information about the tearing effect can be found in http://en.wikipedia.org/wiki/Screen_tearing.

The Freescale i.MX-6 processor contains an anti-tearing mechanism in the IPU unit, which can reduce the tearing effect.
However, since - depending on camera settings and camera model - the frame rate might be very different from the display's refresh rate, tearing effects might still be visible even if the anti-tearing mechanism is active. For applications that are intended to display live camera images on the display, additional measures should be considered to obtain a perfect image quality. This measures can include frame rate control (trimming the camera frame rate to the display's refresh rate), multi-buffering of the camera image etc.

We recommend to activate the anti-tearing mechanism of the i.MX-6 when live camera images are shown on the display.
For evaluation purposes with the development kits, Phytec added GStreamer examples, that use a different kmssink – function, that activates the anti-tearing mechanism.
For more information to "kmssink" parameters type:
- gst-inspect-1.0 kmssink

Note: The kmssink parameter "connector=__" define the output device. If you change the output device e.g. HDMI, set the right parameter.

6 De-Bayering (demosaicking) with NEON CoProcessor

Most of CMOS color chips provide the image in the bayer mosaicing (bayer raw) format. For get a color image in RGB format is it necessary to convert the bayer raw image.
- https://en.wikipedia.org/wiki/Bayer_filter
- https://de.wikipedia.org/wiki/Bayer-Sensor

There are exist different algorithm for converting.
- https://en.wikipedia.org/wiki/Demosaicing

If the microprocessor does not include debayering hardware, have to do the converting via software. For this you need additional processing power and the framerate goes down. It is better to use the NEON coprocessor of the i.MX6. For this support PHYTEC a special function.
It is present as GStreamer plugin "bayer2rgbneon" and in sources for use in an own C-program. We support a simple bilinear algorithm.

For use in GStreamer take "bayer2rgbneon" plugin. For more information to "bayer2rgbneon" parameters type:
- gst-inspect-1.0 bayer2rgbneon

The source are located at:
- https://git.phytec.de/bayer2rgb-neon/

7 OpenCV support

PHYTEC offer an special BSP called "phytec-vision-image...". This version includes OpenCV3.3. For use OpenCV with image output we recommend an additional windows manager. In this case, the user must add the windows manager in BSP and recompile the BSP.
PHYTEC tested openCV with pyCAM cameras and the windows manager X11. Examples of scripts can be found at the following link:
- ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Nunki-i.MX6_linux_PD18.1.x/Software/OpenCV/

If you use the PHYTEC phyCAM - camera modules the camera and the camera interface driver have to configure with the media-ctl tool. Examples are in the scripts at upper link.

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