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	21.08.2015
A1	Describe the settings for camera (in YOCTO PD15.3.0)	H. Fendrich	29.03.2016
A2	Describe the settings for camera (in YOCTO PD16.1.0)	H. Fendrich	17.01.2017
A3	Describe the settings for camera (in YOCTO PD18.1.x)	H. Fendrich	09.08.2018
A4	added VM-016 camera modul	H. Fendrich	27.08.2020

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1 Overview

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

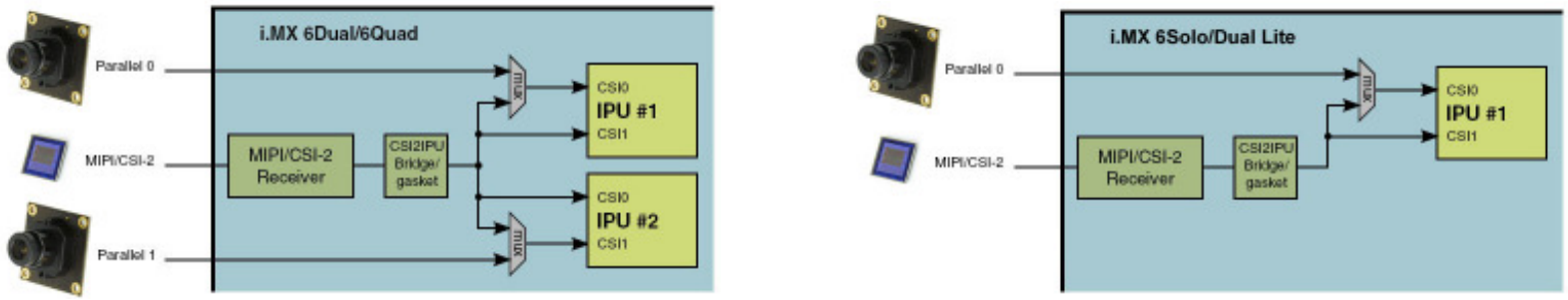

figure 1: Block Diagram Camera Interfaces of i.MX6 Controller (Quad / Dual) and i.MX6 Controller (Solo / Dual Lite)

On the phyCORE-i.MX6 the CSI0/IPU#1 camera path go out as parallel signal.

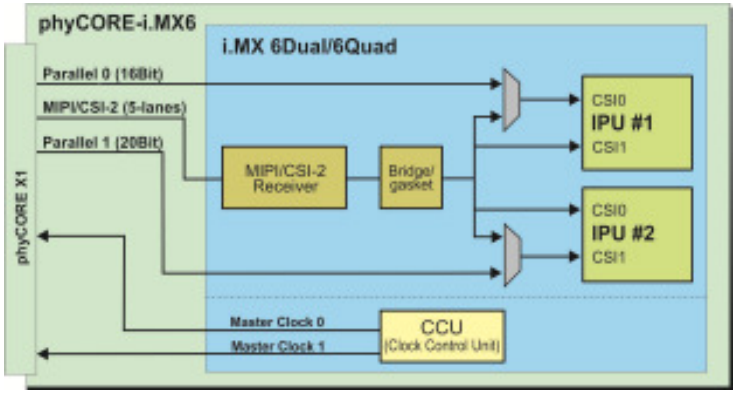

figure 2: Use of Camera_0 (CSI0 of IPU#1) and Camera_1 (CSI1 of IPU#2)

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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 2 and/or phyCAM-S+ see figure 2 or MIPI/CSI-2 interface. For more information to phyCAM-P/S+ see manual L-748.

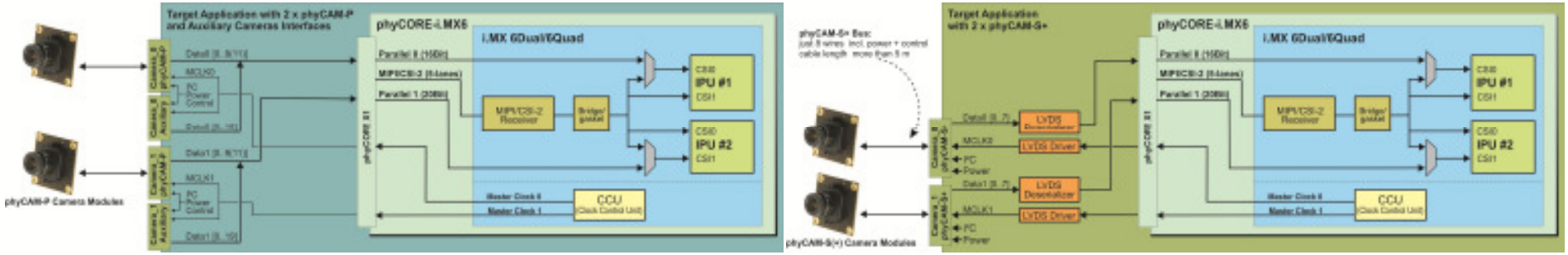

figure 3: Block Diagram of an phyCAM-P solution and an phyCAM-S (+) solution with phyCORE-i.MX6 (Quad / Dual) SBC

On the phyBOARD-Mira baseboard is only the CSI0/IPU#1 camera path (thru a serializer) go out as LVDS signal (see figure 4).
Here you can connect one of the different phyCAM-S(+) camera modules. See the phyCAM-P/-S manual L-748 for more information.

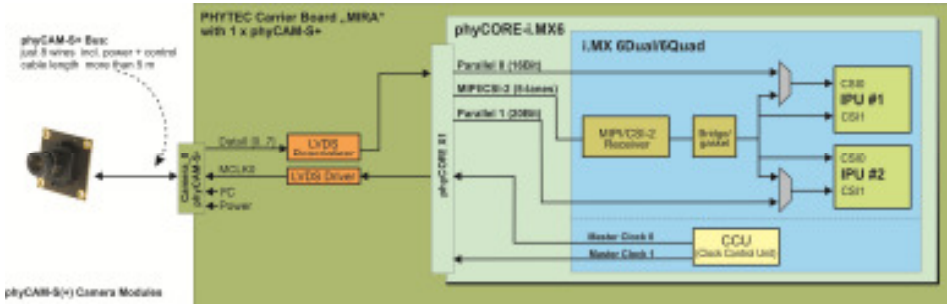

figure 4: Block Diagram of phyCAM-S(+) Camera Interfaces of phyCORE-i.MX6 (Quad / Dual) and the go out on the phyBOARD-MIRA-i.MX6 - SBC

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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 more then one camera interface or/and phyCAM-P support, please use the phyFLEX-i.MX6 Modul.

Note:

The phyBOARD-MIRA features one CSI interface for phyCAM-S(+) camera modules.
Please find more information about the camera support in the path: …\Documentation\...

The kit version KPB-01501-001 is shipped with an i.MX6 controller board which has no camera support installed.
The kit version KPB-01501-002 is shipped with an i.MX6 controller board which has camera support installed.

The Linux BSP for these kits does support the phyCAM-S+ camera series from PHYTEC.
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD15.3.0/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD16.1.0/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD18.1.x/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD20.1.x/

The table below lists the options:

Hardware Configuration		Software Support
phyBOARD Kit	**phyCAM-S+ at CSI_0**	**phyCAM-S+ at CSI_0**
KPB-01501-Video-L01	yes (VM-010-BW-LVDS-M12 is included)	yes
KPB-01501-Video-L02	Yes (phyCAM-S+ camera is selectable)	yes
KPB-01501-001	NM (at base board)	no
KPB-01501-002	yes	yes

NM = no mount

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2 Camera Connectors on the MIRA - Carrier Boards

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

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

On the base board MIRA (PBA-C-06-002) we convert the parallel Camera_0 interface in the phyCAM-S+ camera interface standard (see figure 4). The phyCAM-S+ interface is support on connector X10 (Hirose CAM). Information's to phyCAM-S+ are in the phyCAM-manual (L-748).

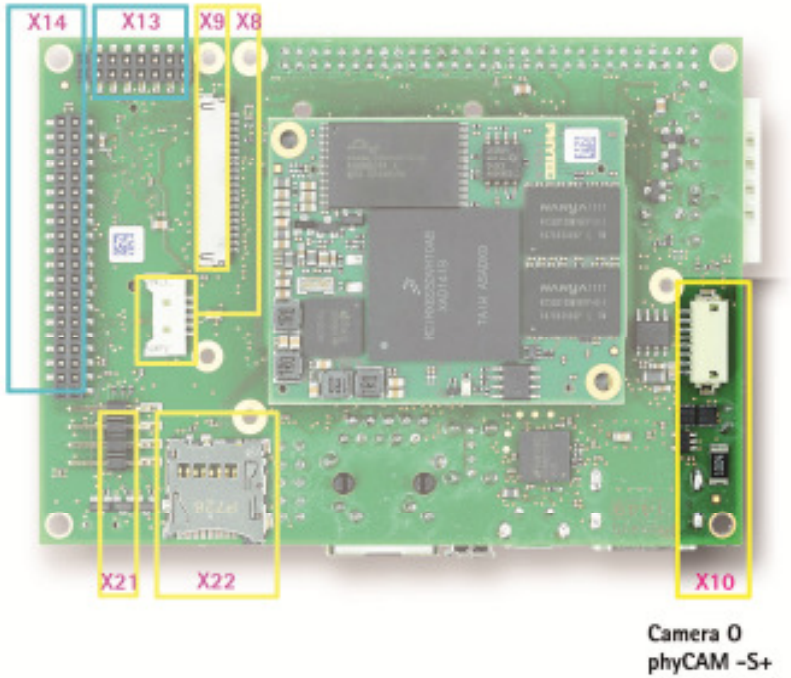

figure 5: Camera Interfaces on phyBOARD-MIRA for the phyCORE-i.MX6 SOM

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3 Change the cameras or camera parameters (YOCTO Linux PD15.2.0)

The Linux BSP PD15.2.0 for these kits does support the camera VM-010-BW-LVDS. For support the other PHYTEC phyCAM-S(+) cameras you have to compile a new device tree.
Even if you want to change the camera master clock or the I2C address of the cameras, you have to compile a new device tree.
For more information see on FTP:
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD15.2.0/

Notes:

- I²C addresses of the camera are set by hardware configuration (jumper setting on the camera and / or on the baseboard. Please refer to the phyCAM-manual L-748 and the hardware manual of the kit.

4 Change the cameras or camera parameters (YOCTO Linux up PD15.3.0 and higher)

Due to the change over to the new linux kernel version, the cameras and the camera interface are no longer supported as a SOC-device, but as 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-Mira-i.MX6_linux_PD15.3.0/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD16.1.0/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD18.1.x/
ftp://ftp.phytec.de/pub/ImageProcessing/phyBOARD-Mira-i.MX6_linux_PD20.1.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>

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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+]
- csix_cam_i2c_address = [0x41-0x5D] depend of camera typ/setings
- 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) [2)]	Not on MIRA board	0	phyCAM-P	VM-006	0x5D, 0x41	of_camera_selection -p 0 -b phyCAM-P -a 0x5D VM-006
	Not on MIRA 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) [2)]	**X10 on MIRA board**	0	phyCAM-S+	VM-006	0x5D, 0x41	of_camera_selection -p 0 -b phyCAM-S+ -a 0x5D VM-006
	Not on MIRA board	1	phyCAM-S+	VM-006	0x5D, 0x41	of_camera_selection -p 1 -b phyCAM-S+ -a 0x5D VM-006
VM-008 [2)]	Not on MIRA board	0	phyCAM-P	VM-008	0x44, 0x45	of_camera_selection -p 0 -b phyCAM-P -a 0x45 VM-008
	Not on MIRA board	1	phyCAM-P	VM-008	0x44, 0x45	of_camera_selection -p 1 -b phyCAM-P -a 0x45 VM-008
	X10 on MIRA board	0	phyCAM-S+	VM-008	0x44, 0x45	of_camera_selection -p 0 -b phyCAM-S+ -a 0x45 VM-008
	Not on MIRA board	1	phyCAM-S+	VM-008	0x44, 0x45	of_camera_selection -p 1 -b phyCAM-S+ -a 0x45 VM-008
VM-009 (-M12 / -H)	Not on MIRA board	0	phyCAM-P	VM-009	0x48, 0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-009
	Not on MIRA board	1	phyCAM-P	VM-009	0x48, 0x5D	of_camera_selection -p 1 -b phyCAM-P -a 0x5D VM-009

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VM-009-LVDS (-M12 / -H)	**X10 on MIRA board**	0	phyCAM-S+	VM-009	0x48, 0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-009
	Not on MIRA 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)	Not on MIRA board	0	phyCAM-P	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-010-BW
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-010-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-010-BW
	Not on MIRA 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)	Not on MIRA board	0	phyCAM-P	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-010-COL
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-010-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-010-COL
	Not on MIRA 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)	Not on MIRA board	0	phyCAM-P	VM-011-BW	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-011-BW
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-011-BW	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-011-BW
	Not on MIRA 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)	Not on MIRA board	0	phyCAM-P	VM-011-COL	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-011-COL
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-011-COL	0x48,0x5D	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-011-COL
	Not on MIRA 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) [1)]	Not on MIRA board	0	phyCAM-P	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-012-BW
	Not on MIRA 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) [1)]	**X10 on MIRA board**	0	phyCAM-S+	VM-012-BW	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-012-BW
	Not on MIRA 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) [1)]	Not on MIRA board	0	phyCAM-P	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-P -a 0x48 VM-012-COL
	Not on MIRA 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) [1)]	**X10 on MIRA board**	0	phyCAM-S+	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 0 -b phyCAM-S+ -a 0x48 VM-012-COL
	Not on MIRA board	1	phyCAM-S+	VM-012-COL	0x48, 0x4C, 0x58, 0x5C	of_camera_selection -p 1 -b phyCAM-S+ -a 0x48 VM-012-COL

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**.**
- If the CSI1 port not is used, please select "none" or the same camera as at CSI0 (with other I²C-adress).

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- [1]) at PD15.3.0 progress, at PD16.1.0 present
- [2]) at PD18.1.0 not present

4.1 Change the cameras or camera parameters for VM-016 camera series (YOCTO Linux PD20.1.0 and higher)

For the other cameras are the syntax equal as in chapter 4.

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)	Not on MIRA board	0	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-P -a 0x10 VM-016
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-S+ -a 0x10 VM-016
	Not on MIRA 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)	Not on MIRA board	0	phyCAM-P	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-P -a 0x10 VM-016
	Not on MIRA 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)	**X10 on MIRA board**	0	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 0 -b phyCAM-S+ -a 0x10 VM-016
	Not on MIRA board	1	phyCAM-S+	VM-016	0x10, 0x18	of_camera_selection -p 1 -b phyCAM-S+ -a 0x10 VM-016

5 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 an 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".

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6 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 fbsink – function, that activates the anti-tearing mechanism.

6.1 GStreamer function for improved Tearing reduction (Linux up PD16.1.0)

From PD16.1.0 the GStreamer contains the "kmssink" plugin.
This plugin reduce the tearing. Most of the Phytec GStreamer example scripts use this plugin. Please show the scripts in path ../gstreamer_examples/.. .
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 outputdevice e.g. HDMI, set the right parameter.

7 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

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- 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/

8 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-Mira-i.MX6_linux_PD18.1.x/Software/OpenCV/

Note: At PD20.1.0 is the X11 windows manager and openCV examples are include in the image. A recompile is not necessary.

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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