

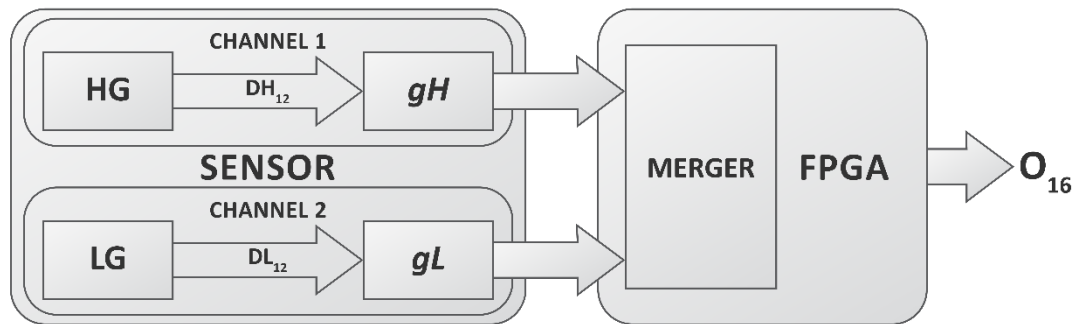
sCMOS camera modes.

Gpixel sensors (GSENSE6060, GSENSE2020, GSENSE5130 and others) have different operation modes, HDR, STD and CMS. Sensors have two pixel channels and on-chip 12bit or 14bit ADCs. Channels can operate in two modes, first high gain (HG) is optimized for low readout noise, second low gain (LG) is optimized for full well capacity.

1. HDR modes.

In HDR mode analog gains are fixed (g_L and g_H) and can't be changed by API.

1. HDR HG LG.



$$O_{16} = (DL_{12} * k + DH_{12} * (1 - k) * g) * 16 = DL_{12} * k * 16 + DH_{12} * (1 - k) * g * 16$$

there:

O_{16} – 16bit output signal.

DL_{12} - 12bit data of Channel2 (LG mode).

DH_{12} - 12bit data of Channel1 (HG mode).

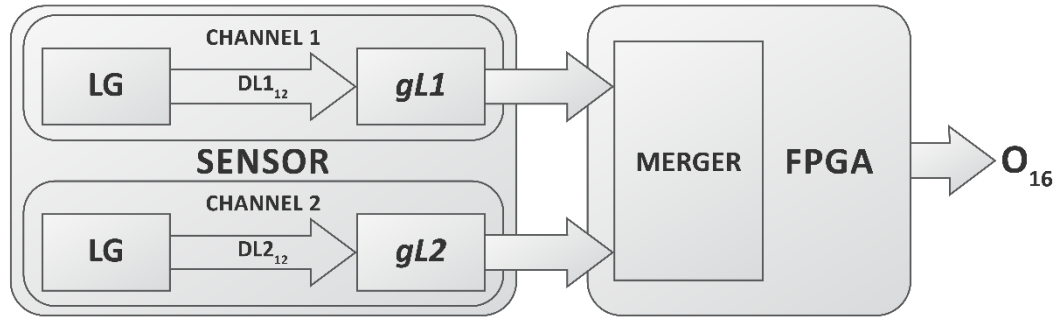
$k = DH_{12} / 4095$.

$g = g_L / g_H$.

g_L – Analog gain of Channel2.

g_H – Analog gain of Channel1.

2. HDR LG.



$$O_{16} = (DL2_{12} * k + DL1_{12} * (1 - k) * g) * 16 = DL2_{12} * k * 16 + DL1_{12} * (1 - k) * g * 16$$

there:

O_{16} – 16bit output signal.

$DL1_{12}$ - 12bit data of Channel1 (LG mode).

$DL2_{12}$ - 12bit data of Channel2 (LG mode).

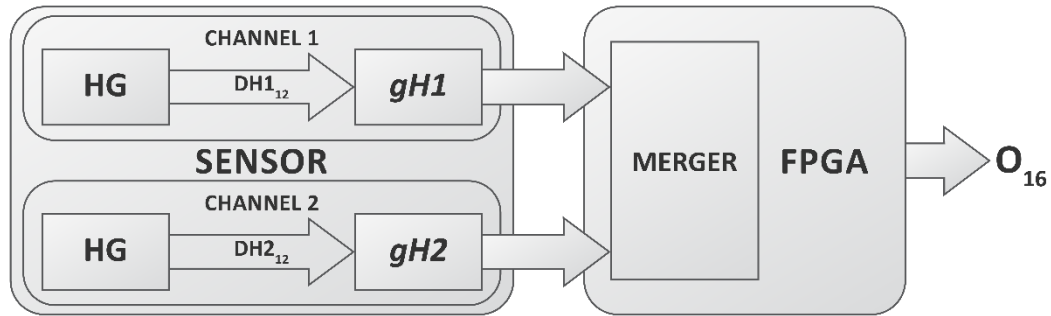
$k = DL1_{12} / 4095$.

$g = gL2 / gL1$.

$gL1$ – Analog gain of Channel1.

$gL2$ – Analog gain of Channel2.

3. HDR HG.



$$O_{16} = (DH2_{12} * k + DH1_{12} * (1 - k) * g) * 16 = DH2_{12} * k * 16 + DH1_{12} * (1 - k) * g * 16$$

there:

O_{16} – 16bit output signal.

$DH1_{12}$ - 12bit data of Channel1 (HG mode).

$DH2_{12}$ - 12bit data of Channel2 (HG mode).

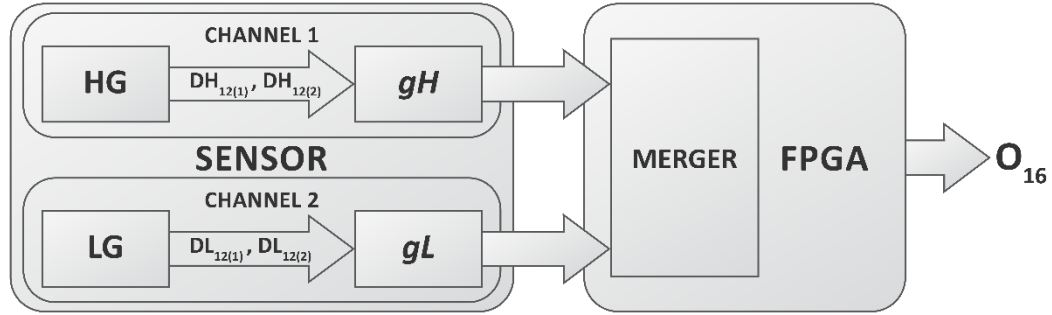
$k = DH1_{12} / 4095$.

$g = gH2 / gH1$.

$gH1$ – Analog gain of Channel1.

$gH2$ – Analog gain of Channel2.

4. HDR + CMS2.



$$O_{16} = ((DL_{12(1)} + DL_{12(2)}) * k + (DH_{12(1)} + DH_{12(2)}) * (1 - k) * g) * 16 = (DL_{12(1)} + DL_{12(2)}) * k * 16 + (DH_{12(1)} + DH_{12(2)}) * (1 - k) * g * 16$$

there:

O_{16} – 16bit output signal.

$DL_{12[1]}$ – First sample of 12bit data of Channel2 (LG mode).

$DL_{12[2]}$ – Second sample of 12bit data of Channel2 (LG mode).

$DH_{12[1]}$ – First sample of 12bit data of Channel1 (HG mode).

$DH_{12[2]}$ – Second sample of 12bit data of Channel1 (HG mode).

$k = DH_{12} / 4095$.

$g = gL / gH$.

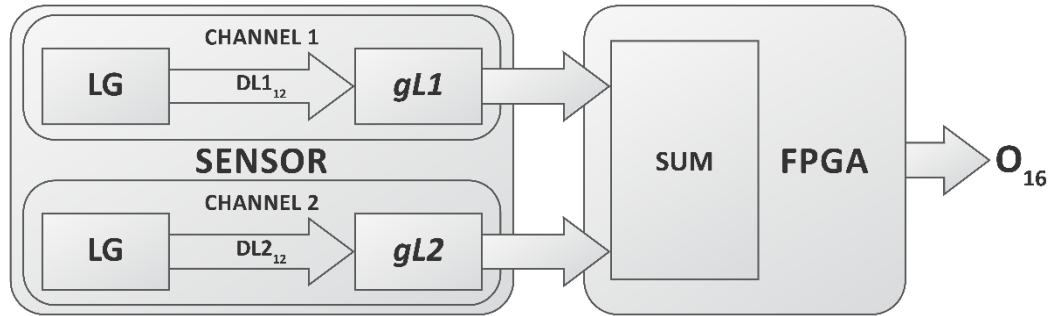
gL – Analog gain of Channel2.

gH – Analog gain of Channel1.

2. CMS modes.

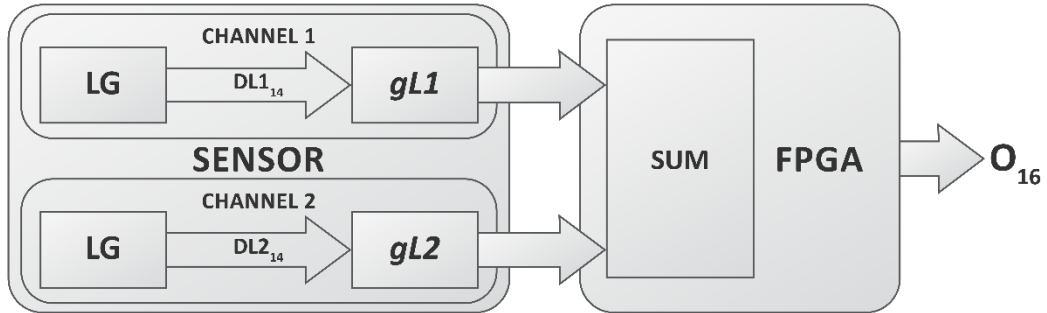
In CMS and STD modes gain on both channels can be changed by API.

1. CMS2 12bit LG.



$$O_{16} = (DL1_{12} * gL1 + DL2_{12} * gL2) * 8 = D_{13} * 8$$

2. CMS2 14bit LG.



$$O_{16} = (DL1_{14} * gL1 + DL2_{14} * gL2) * 4 = D_{14} * 4$$

there:

O_{16} – 16bit output signal.

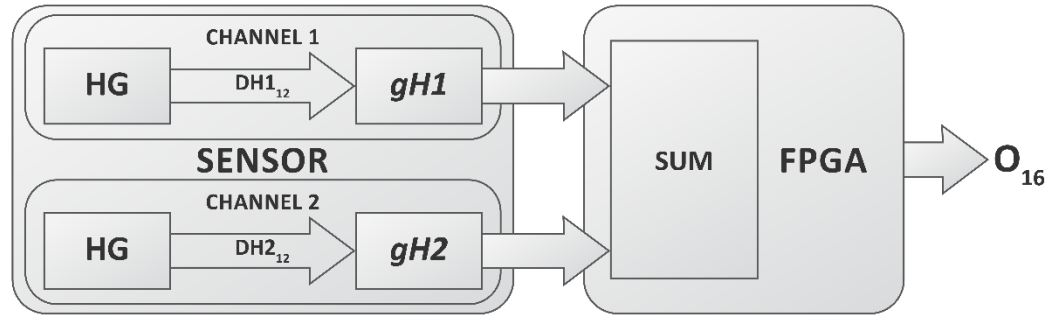
$DL1_{12}$ - 12bit data of Channel1 (LG mode).

$DL2_{12}$ - 12bit data of Channel2 (LG mode).

$DL1_{14}$ - 14bit data of Channel1 (LG mode).

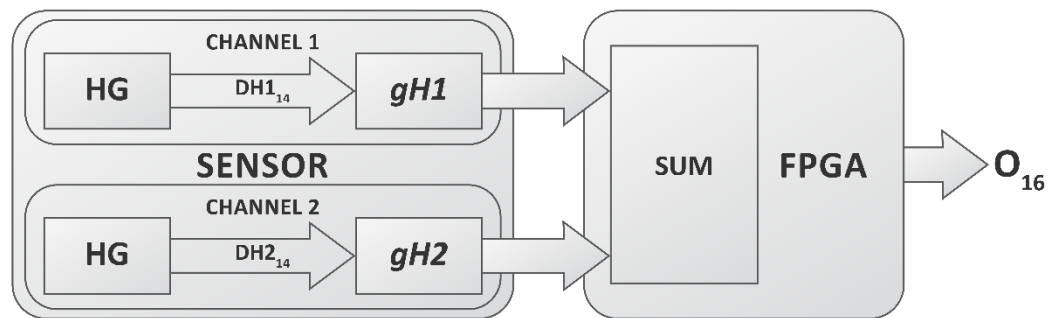
$DL2_{14}$ - 14bit data of Channel2 (LG mode).

3. CMS2 12bit HG.



$$O_{16} = (DH1_{12} * gH1 + DH2_{12} * gH2) * 8 = D_{13} * 8$$

4. CMS2 14bit HG.



$$O_{16} = (DH1_{14} * gH1 + DH2_{14} * gH2) * 4 = D_{14} * 4$$

there:

O_{16} – 16bit output signal.

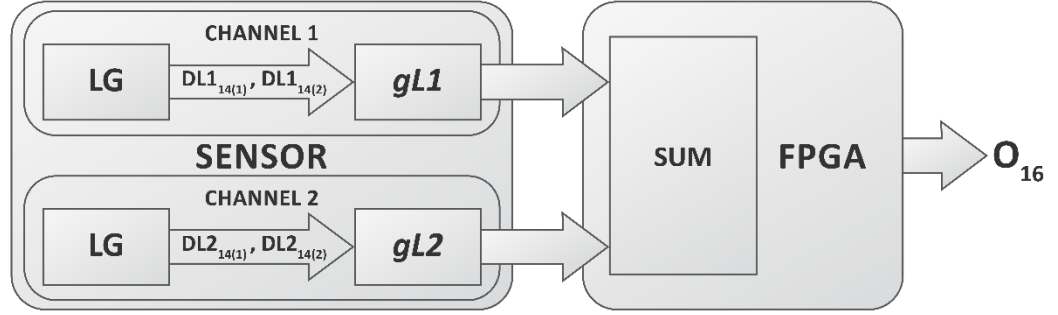
$DH1_{12}$ - 12bit data of Channel1 (LG mode).

$DH2_{12}$ - 12bit data of Channel2 (LG mode).

$DH1_{14}$ - 14bit data of Channel1 (LG mode).

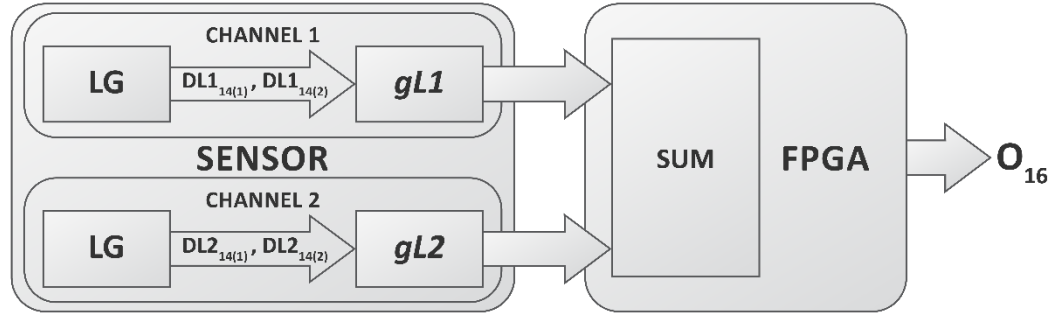
$DH2_{14}$ - 14bit data of Channel2 (LG mode).

5. CMS4 12bit LG.



$$O_{16} = ((DL1_{12(1)} + DL1_{12(2)}) * gL1 + (DL2_{12(1)} + DL2_{12(2)}) * gL2) * 4 = D_{14} * 4$$

6. CMS4 14bit LG.



$$O_{16} = ((DL1_{14(1)} + DL1_{14(2)}) * gL1 + (DL2_{14(1)} + DL2_{14(2)}) * gL2) = D_{16}$$

there:

O_{16} – 16bit output signal.

$DL1_{12[1]}$ – First sample of 12bit data of Channel1 (LG mode).

$DL1_{12[2]}$ – Second sample of 12bit data of Channel1 (LG mode).

$DL2_{12[1]}$ – First sample of 12bit data of Channel2 (LG mode).

$DL2_{12[2]}$ – Second sample of 12bit data of Channel2 (LG mode).

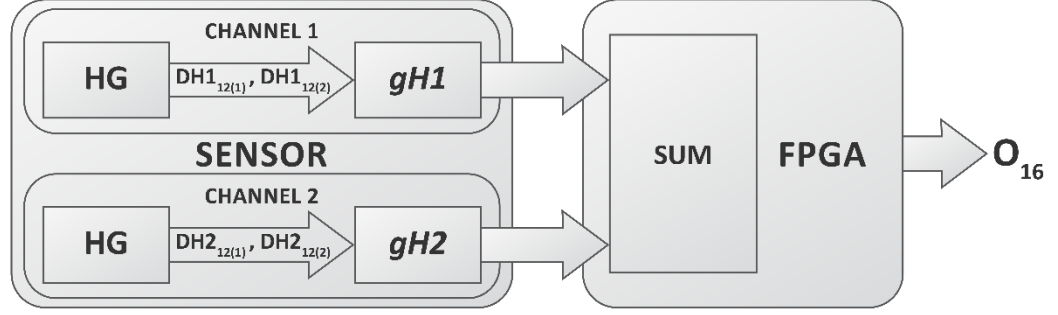
$DL1_{14[1]}$ – First sample of 14bit data of Channel1 (LG mode).

$DL1_{14[2]}$ – Second sample of 14bit data of Channel1 (LG mode).

$DL2_{14[1]}$ – First sample of 14bit data of Channel2 (LG mode).

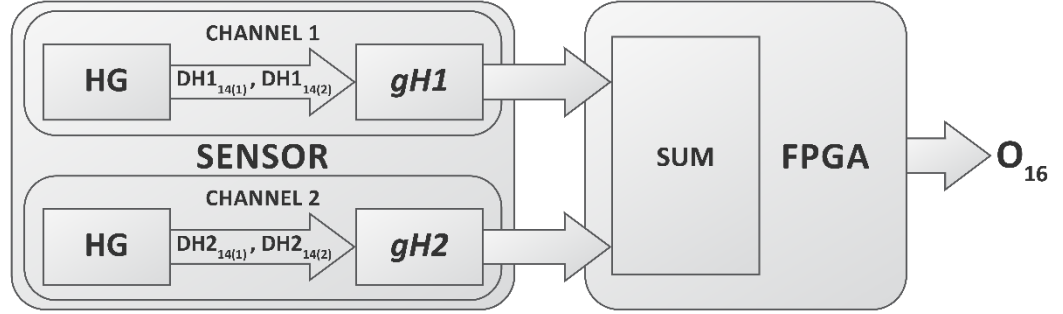
$DL2_{14[2]}$ – Second sample of 14bit data of Channel2 (LG mode).

7. CMS4 12bit HG.



$$O_{16} = ((DH1_{12(1)} + DH1_{12(2)}) * gH1 + (DH2_{12(1)} + DH2_{12(2)}) * gH2) * 4 = D_{14} * 4$$

8. CMS4 14bit HG.



$$O_{16} = ((DH1_{14(1)} + DH1_{14(2)}) * gH1 + (DH2_{14(1)} + DH2_{14(2)}) * gH2) = D_{16}$$

there:

O_{16} – 16bit output signal.

$DH1_{12[1]}$ – First sample of 12bit data of Channel1 (HG mode).

$DH1_{12[2]}$ – Second sample of 12bit data of Channel1 (HG mode).

$DH2_{12[1]}$ – First sample of 12bit data of Channel2 (HG mode).

$DH2_{12[2]}$ – Second sample of 12bit data of Channel2 (HG mode).

$DH1_{14[1]}$ – First sample of 14bit data of Channel1 (HG mode).

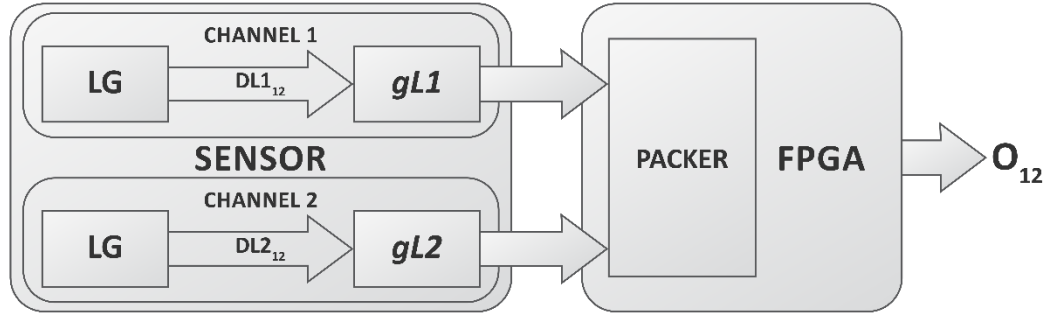
$DH1_{14[2]}$ – Second sample of 14bit data of Channel1 (HG mode).

$DH2_{14[1]}$ – First sample of 14bit data of Channel2 (HG mode).

$DH2_{14[2]}$ – Second sample of 14bit data of Channel2 (HG mode).

3. STD modes.

1. STD 12bit LG.



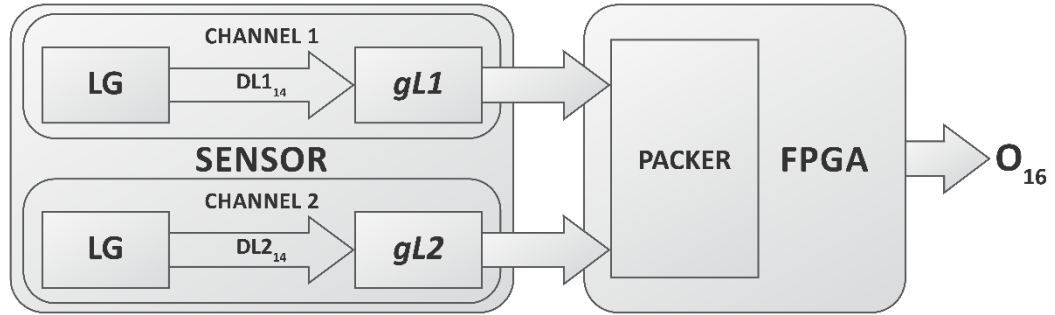
$$O_{12}(\text{pixel } 0) = DL1_{12}(\text{pixel } 0, \text{row } 0) * gL1$$

$$O_{12}(\text{pixel } 1) = DL2_{12}(\text{pixel } 0, \text{row } 1) * gL2$$

$$O_{12}(\text{pixel } 2) = DL1_{12}(\text{pixel } 1, \text{row } 0) * gL1$$

$$O_{12}(\text{pixel } 3) = DL2_{12}(\text{pixel } 1, \text{row } 1) * gL2$$

2. STD 14bit LG.



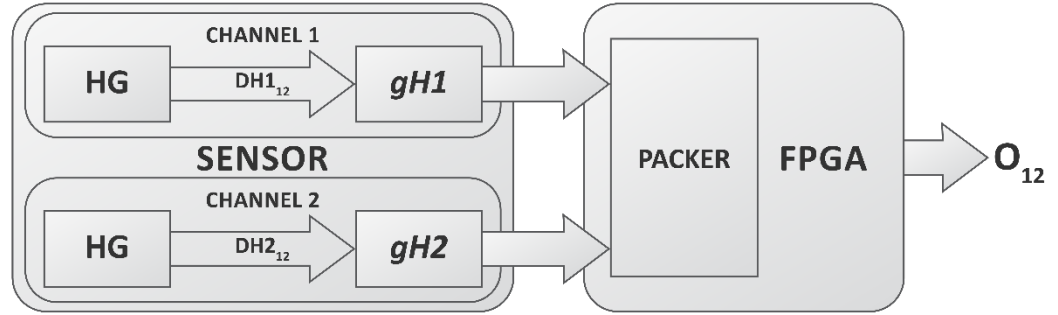
$$O_{16}(\text{pixel } 0) = DL1_{14}(\text{pixel } 0, \text{row } 0) * gL1 * 4$$

$$O_{16}(\text{pixel } 1) = DL2_{14}(\text{pixel } 0, \text{row } 1) * gL2 * 4$$

$$O_{16}(\text{pixel } 2) = DL1_{14}(\text{pixel } 1, \text{row } 0) * gL1 * 4$$

$$O_{16}(\text{pixel } 3) = DL2_{14}(\text{pixel } 1, \text{row } 1) * gL2 * 4$$

3. STD 12bit HG.



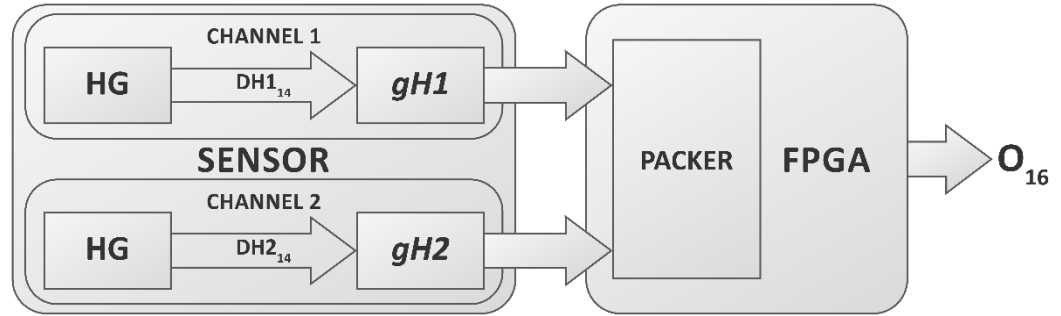
$$O_{12}(\text{pixel } 0) = DH1_{12}(\text{pixel } 0, \text{row } 0) * gH1$$

$$O_{12}(\text{pixel } 1) = DH2_{12}(\text{pixel } 0, \text{row } 1) * gH2$$

$$O_{12}(\text{pixel } 2) = DH1_{12}(\text{pixel } 1, \text{row } 0) * gH1$$

$$O_{12}(\text{pixel } 3) = DH2_{12}(\text{pixel } 1, \text{row } 1) * gH2$$

4. STD 14bit HG.



$$O_{16}(\text{pixel } 0) = DH1_{14}(\text{pixel } 0, \text{row } 0) * gH1 * 4$$

$$O_{16}(\text{pixel } 1) = DH2_{14}(\text{pixel } 0, \text{row } 1) * gH2 * 4$$

$$O_{16}(\text{pixel } 2) = DH1_{14}(\text{pixel } 1, \text{row } 0) * gH1 * 4$$

$$O_{16}(\text{pixel } 3) = DH2_{14}(\text{pixel } 1, \text{row } 1) * gH2 * 4$$