



life.augmented

A photograph of a stage with numerous spotlights. The lights are primarily yellow and orange, with some green lights visible in the upper right. The beams of light create a dramatic atmosphere.

VD6283 ST Ambient Light sensor

STMicroelectronics

신진욱 부장

Agenda

1

VD6283 ALS function, flicker detecting and module info

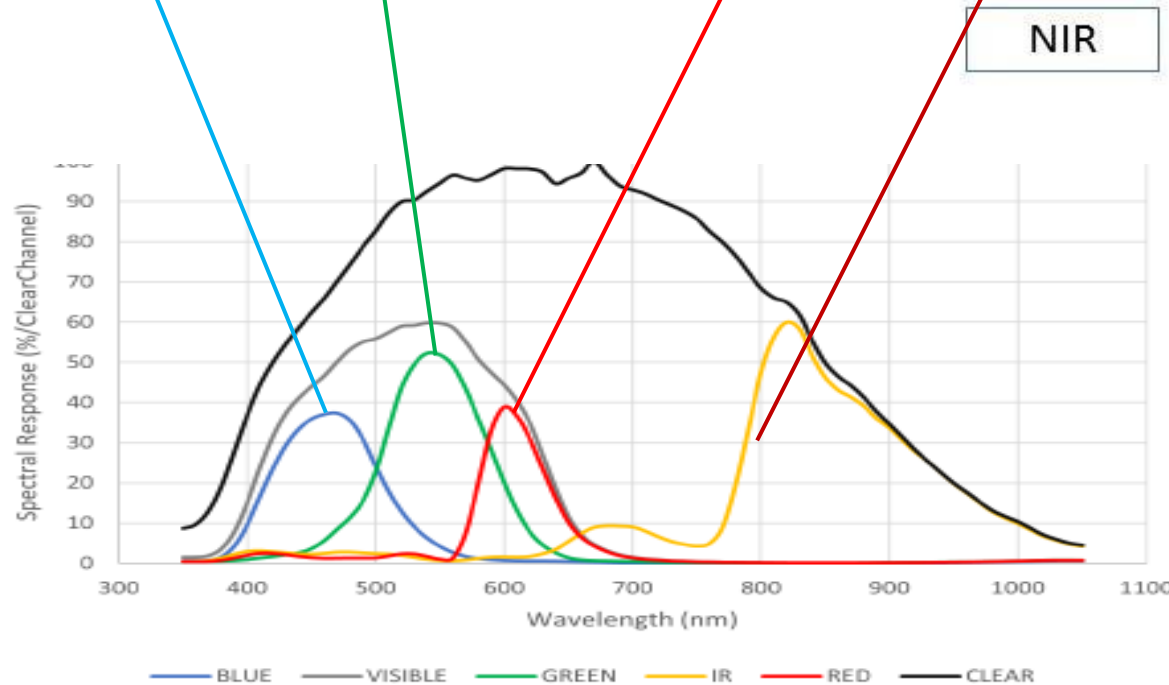
2

VD6283 Windows GUI introduction

3

Q&A

VD6283TX | Light Spectrum



NIR

FIR



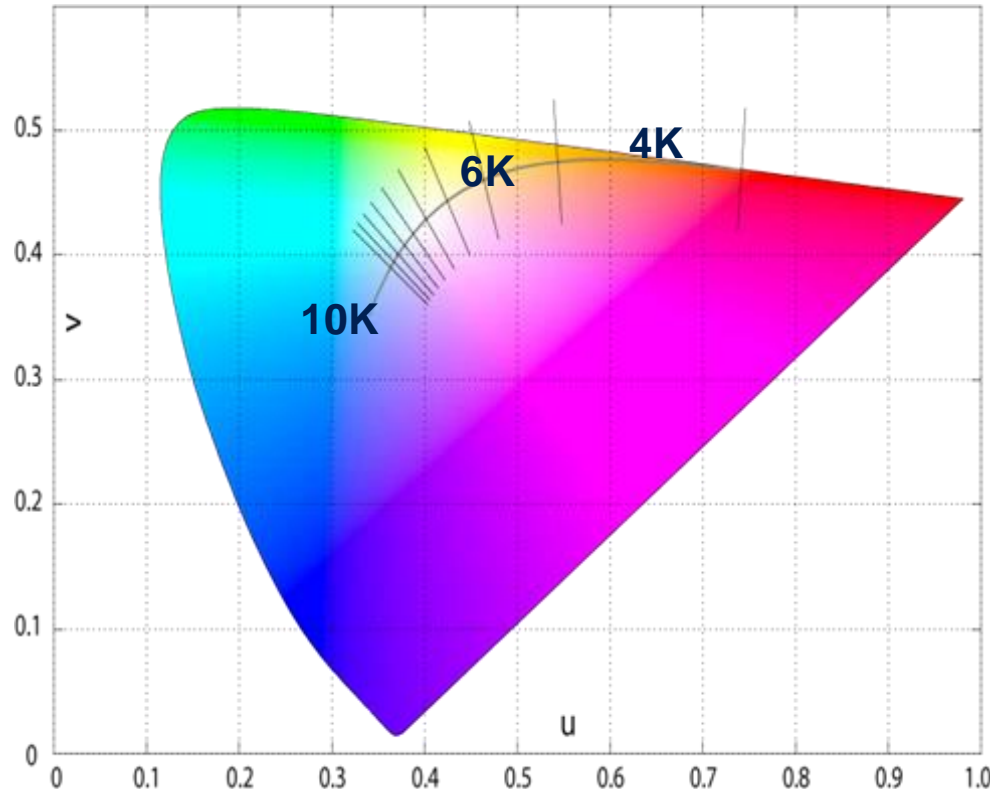
VD6283TX | What is color temperature

- **Color temperature of a color** = temperature (Kelvin) of a black body radiator (e.g. heated metal bar) that has the same color
 - Concerned colors: orange->yellow->white->blue (see on next slide)
- It is widely used to describe the appearance of common illuminants, as illustrated on the picture below (from Wikipedia)
- The color temperature describes the color itself, not the spectral power distribution: artificial lights often have a SPD very different from that of a black body radiator
- **Warning:** low temperature colors are often called “warm” colors (and vice-versa), due to the fact that typical low temp illuminants also emit IR radiations (candle, light bulb...), and daylight color temperature is higher in winter



VD6283 | Colour temperature

- Colour Temperature = Colour of Light Source
 - (Approximate) Colour information using 1 variable
 - Most light sources close to this line, but not always exactly on it

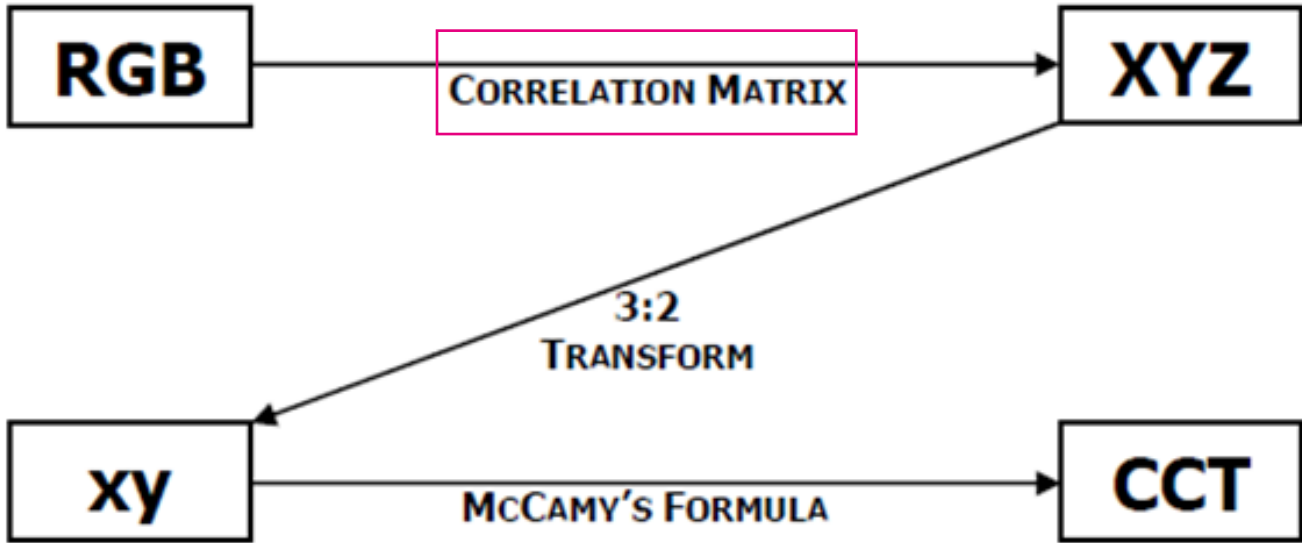
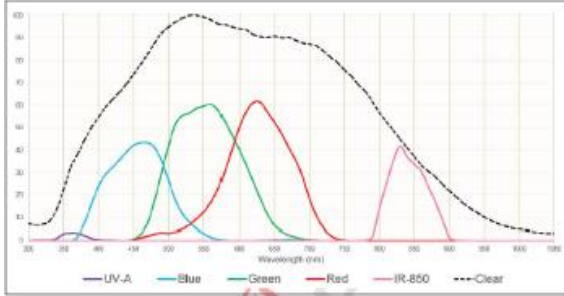


Temperature of “black body” radiator that matches colour of light source

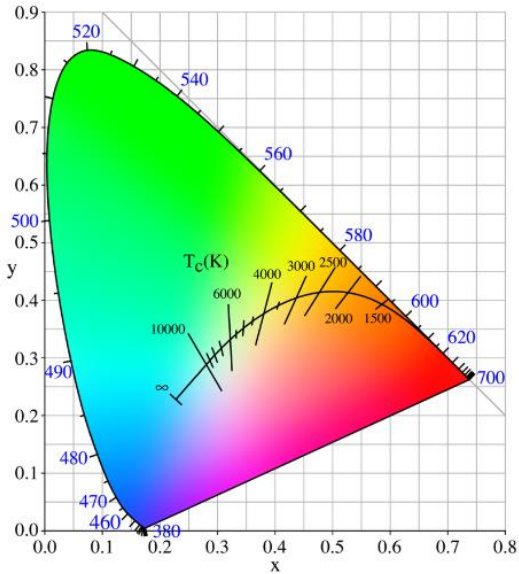
Examples	
3300K	Incandescent Light Bulb
4000K	Xenon Arc
5000K	Horizon Daylight
6000K	Flash
6500K	Noon Daylight (D65)
9300K	CRT screen

VD6283TX | CCT computation

From Sensor....



... to Color Temperature



VD6283TX | XYZ, (x,y) & CCT

- Example of correlation exercise performed on following lights:

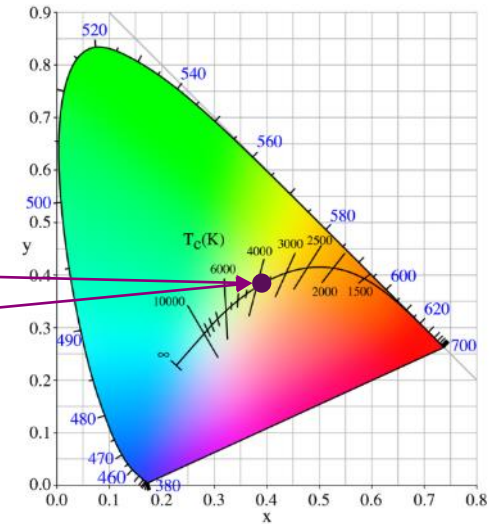
- A, D65 and WhiteLED 4000K

$$\begin{pmatrix} X \\ Y \\ Z \end{pmatrix} = \begin{pmatrix} R \\ G \\ B \end{pmatrix} \cdot \begin{matrix} \text{Correlation Matrix} \\ \begin{pmatrix} C_1 & C_2 & C_3 \\ C_4 & C_5 & C_6 \\ C_7 & C_8 & C_9 \end{pmatrix} \end{matrix}$$



(x, y) Chromaticity (CIE1931)

- $x = X / (X+Y+Z)$
- $y = Y / (X+Y+Z)$



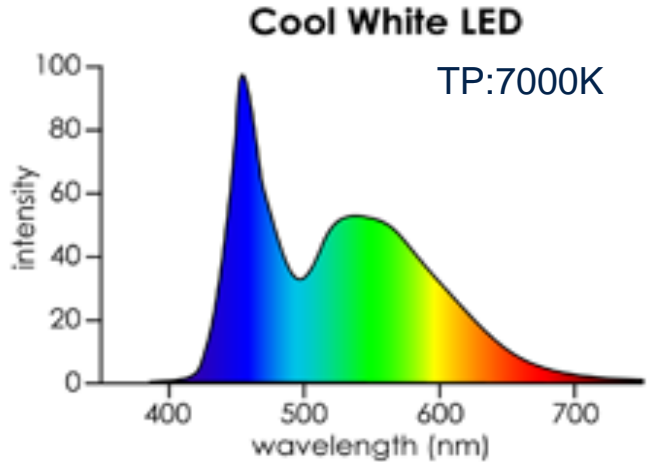
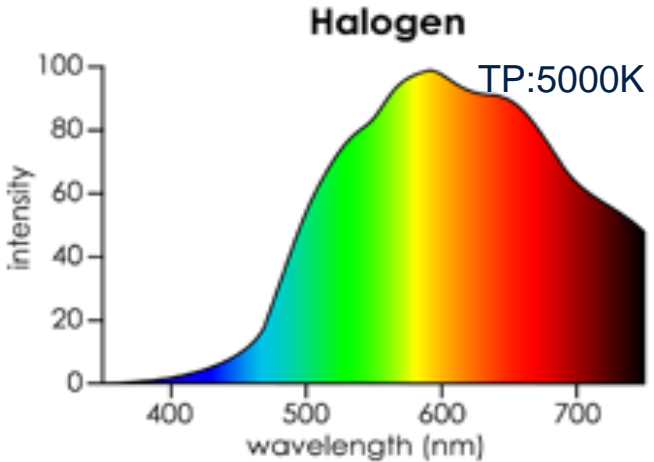
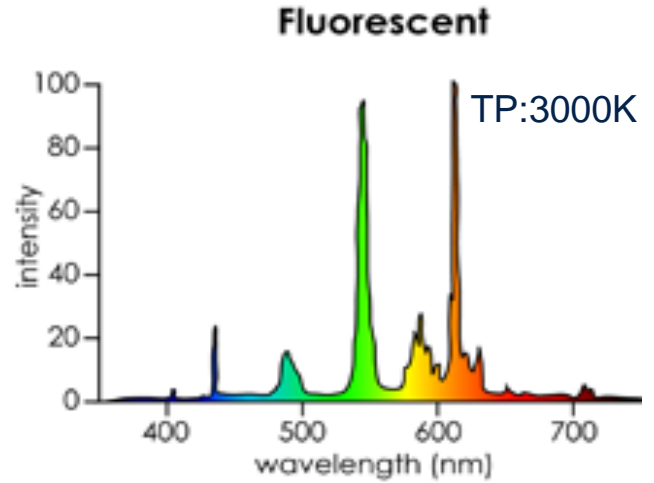
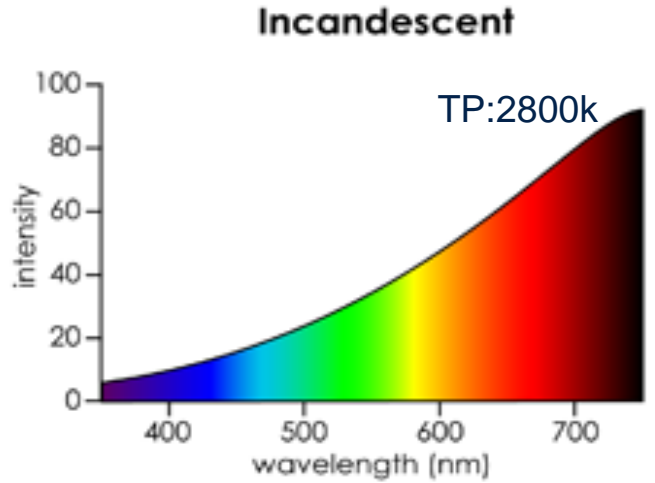
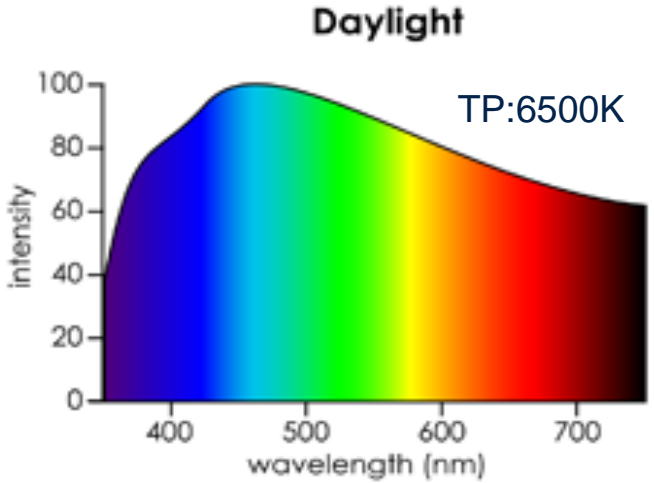
Correlated Color Temperature (in Kelvins)
 $CCT = 449n^3 + 3525n^2 + 6823.3n + 5520.33$

where $n = (x - 0.3320) / (0.1858 - y)$

$$\begin{aligned} X &= R * C_1 + G * C_2 + B * C_3 \\ Y &= R * C_4 + G * C_5 + B * C_6 \\ Z &= R * C_7 + G * C_8 + B * C_9 \end{aligned}$$

Y = Illuminance (Lux)

VD6283TX | Standard illuminants



VD6283TX | Correlation matrix

Goal: Convert RGB values into XYZ space thanks to a correlation matrix built upon several lights.



Spectrophotometer
X, Y, Z values
(+ x, y, CCT)



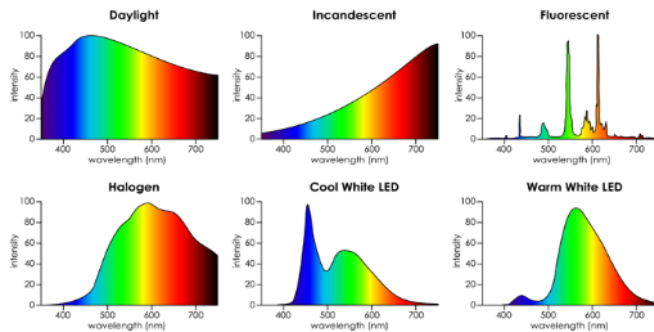
$$\begin{bmatrix} X_{\text{light}_1} & X_{\text{light}_2} & \dots & X_{\text{light}_n} \\ Y_{\text{light}_1} & Y_{\text{light}_2} & \dots & Y_{\text{light}_n} \\ Z_{\text{light}_1} & Z_{\text{light}_2} & \dots & Z_{\text{light}_n} \end{bmatrix}$$

•

$$\begin{bmatrix} C_{R_{\text{light}_1}} & C_{R_{\text{light}_2}} & \dots & C_{R_{\text{light}_n}} \\ C_{G_{\text{light}_1}} & C_{G_{\text{light}_2}} & \dots & C_{G_{\text{light}_n}} \\ C_{B_{\text{light}_1}} & C_{B_{\text{light}_2}} & \dots & C_{B_{\text{light}_n}} \end{bmatrix}^{-1}$$

=

Correlation Matrix

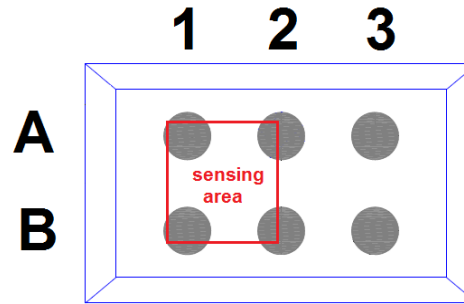
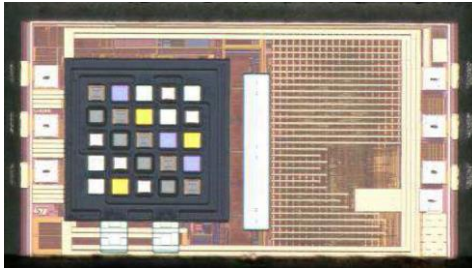


Rainbow 2
R, G, B counts
(+Gain, Expo)



VD6283TX | Device pinout

- **Top view** (balls down, glass up)



Ball number	Signal name	Signal type	Typ. Voltage	Description
A1	VDD	Main supply	VDD	Supply, to be connected to main supply
A2	SDA	Digital input/output	VDD	I2C serial data
A3	VSS	Ground	GND	To be connected to main ground
B1	GPIO2	Digital input/output	VDD	PDM input clock or AC flicker signal output
B2	GPIO1	Digital input/output	VDD	Interrupt output or Digital PDM signal output
B3	SCL	Digital input	VDD	I2C serial clock

VD6283TX | Photodiode matrix

C	VIS	R	G	
IR	C	B	R	G
G	IR	C	VIS	B
R	G	IR	C	VIS
	B	G	IR	C

VD6283TX

Flicker Detection Function



VD6283TX | Flicker definition

- **Flicker** is the pulsating or fluctuating light phenomenon of artificial light sources.
 - Most types of artificial lights will emit flicker when connected to the power mains (home / business office)



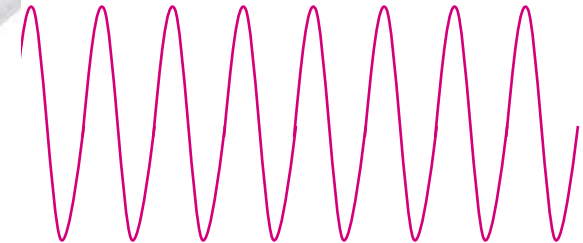
Common 60W
Incandescent Bulb



Common 14W
CFL Bulb



Philips 12.5W
AmbientLED Bulb



- In modern lightings, flickering is hardly noticeable to human eyes.



It's not because you don't see Flicker means there isn't Flicker!

VD6283TX | LEDs are everywhere ! Flicker challenge

Lighting systems evolve. LEDs becomes the tricky challenge for camera ISP !



18%
2013 LED Reach
Predicted global LED market reach

31%
2015 LED Reach
Predicted global LED market reach

70%
2020 LED Reach
Predicted global LED market reach



50Hz / 60Hz
sinewave flicker

70%

100Hz / 2KHz
(square flicker)

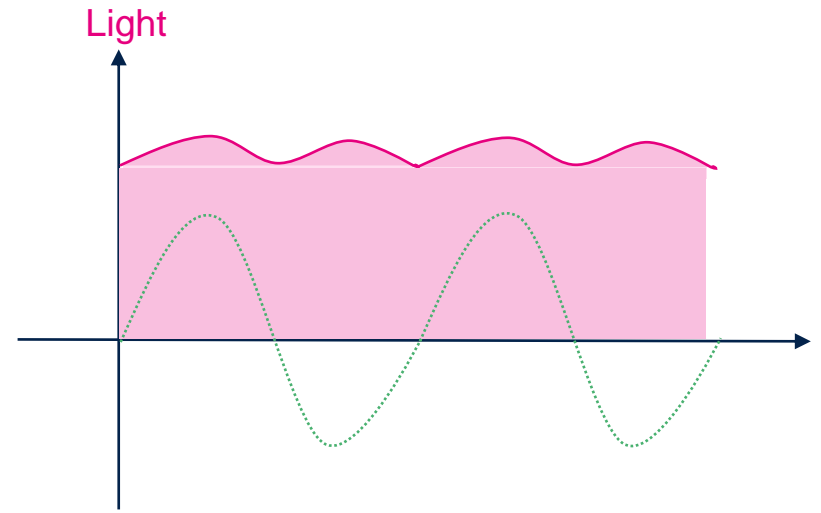
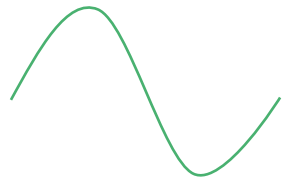


LEDLights.co.uk



VD6283TX | Flicker – 50/60Hz vs. 100/120Hz

Power Mains frequency:
50Hz or 60Hz



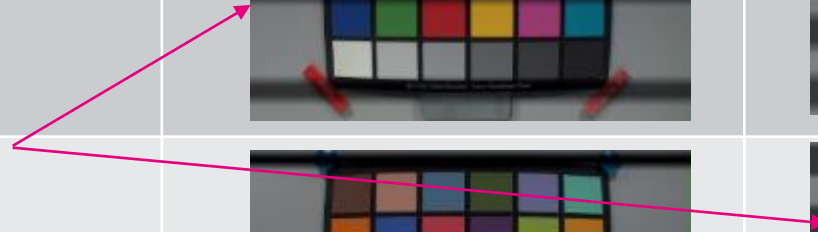
Light "Flicker" frequency = $50/60\text{Hz} * 2$

100Hz / 120Hz

VD6283/TX | Pulsed LED light impact “Stripes effect” versus frequency value and duty cycle

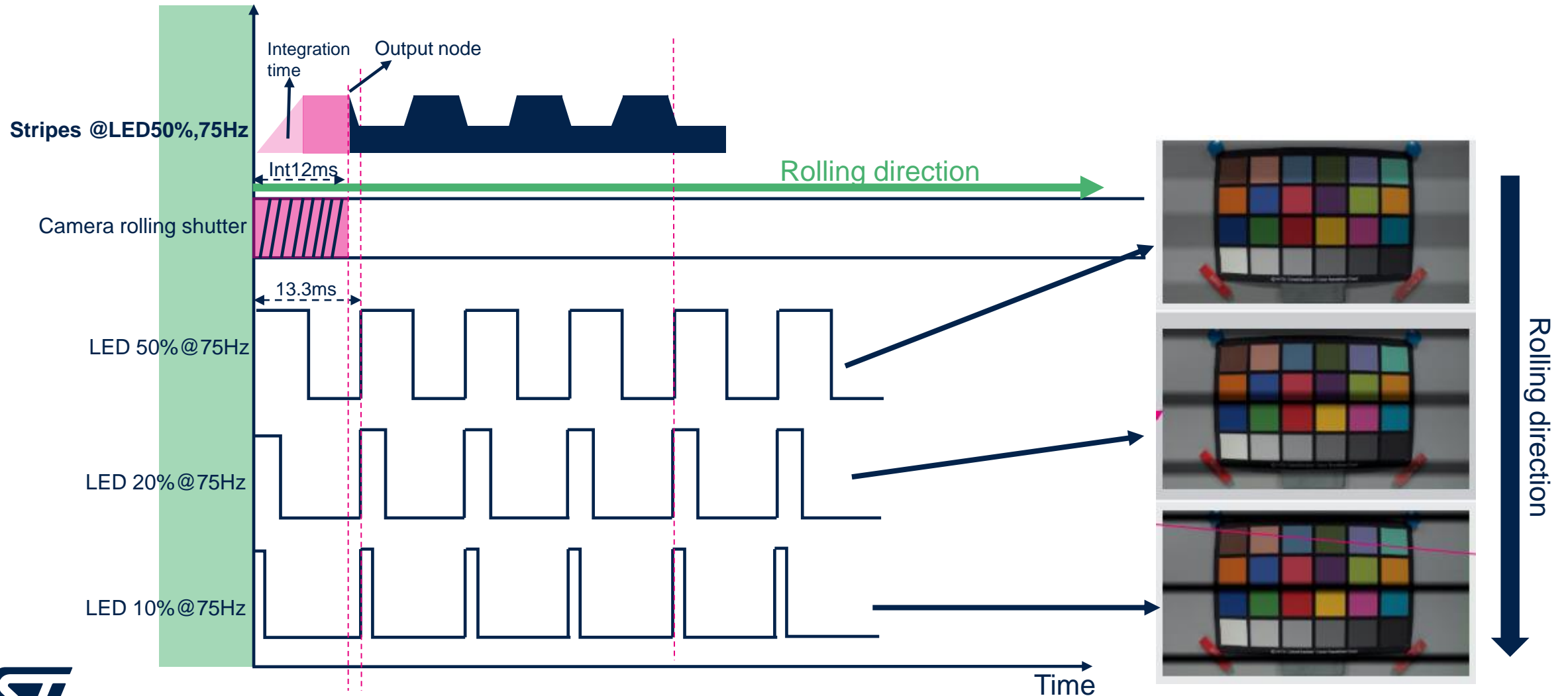
LED frequency ►	75Hz	125Hz	200Hz
▼ Duty Cycle			
50%			
20%			
10%			

stripes



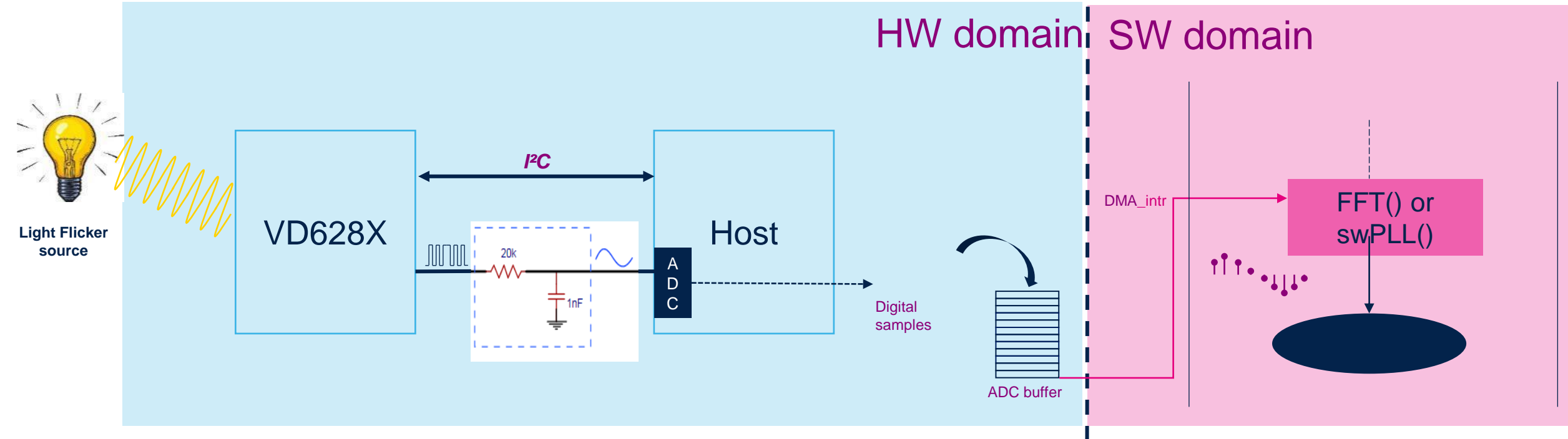
- **Camera Sensor:** Tint = 12ms ; Line period = 0.028ms; framerate = 25fps
- **Light LED:** 75, 125 or 200 Hz ; duty cycle = 10, 20 or 50%
- ST algo team can provide guidelines to select the right Expo / Framerate once flicker frequency is known

VD6283TX | Pulsed LED light impact Stripes explanation



VD6283TX | Flicker extraction w/ ADC

VD6283TX Support Analog output only



One hardware, two software solutions:

1. Software PLL():

- ✓ Optimized solution for 50/60Hz detection
- ✓ Faster detection time (<80ms including autogain algo)
- ✓ Smaller CPU load

2. FFT (Fast Fourier Transform):

- ✓ 100Hz to 2Khz Flicker detection
- ✓ Capability to detect multi-tone frequencies

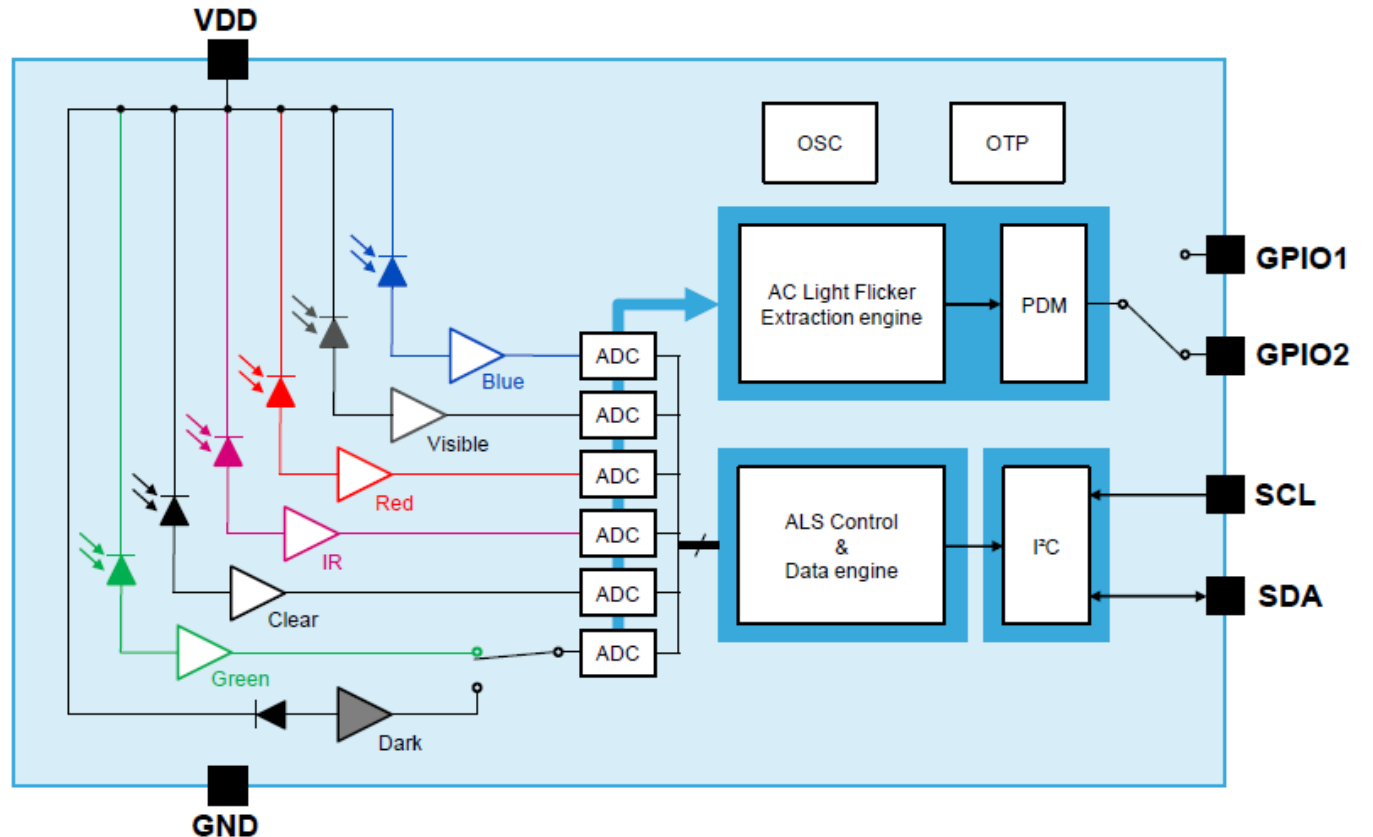
VD6283TX

Module Introduction

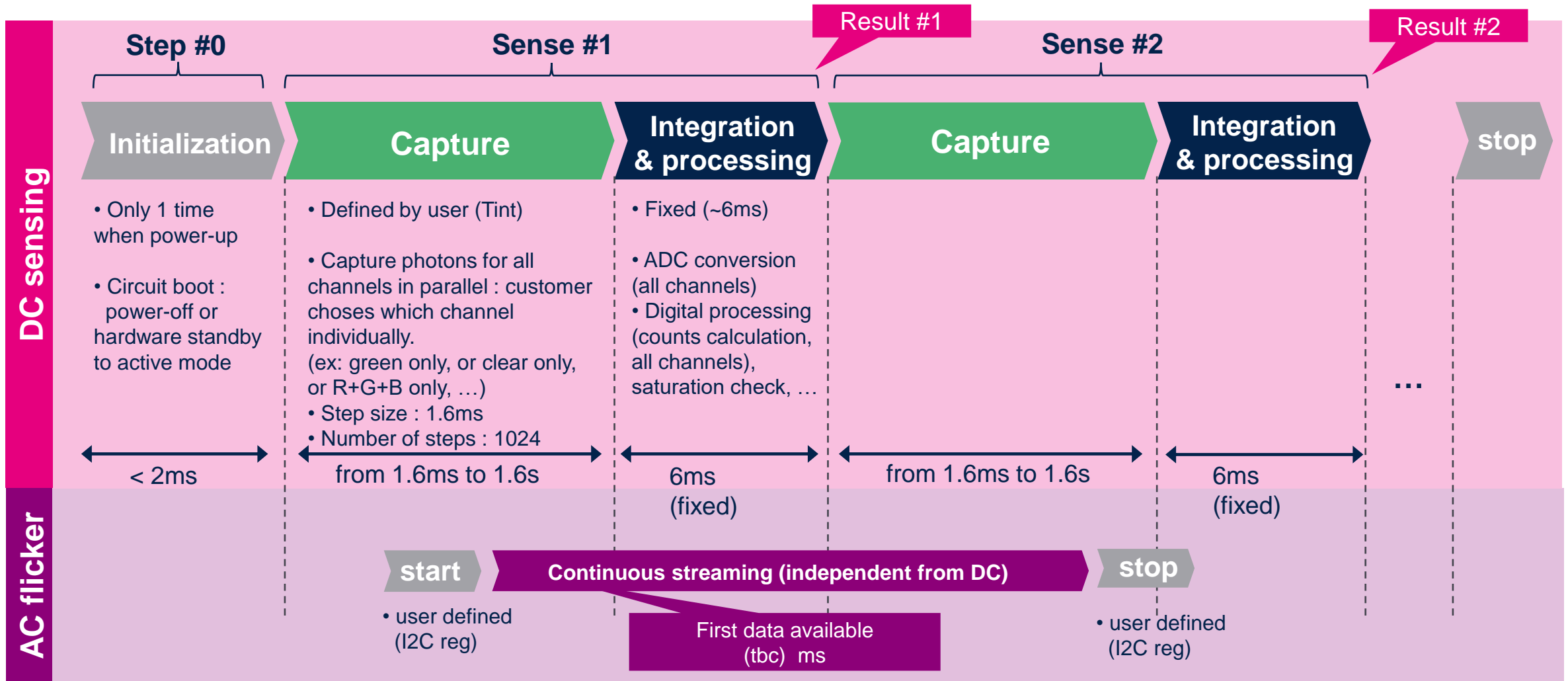


VD6283TX | Function diagram

- **VDD:** 1.8V
- **OSC:** 10MHz
- **OTP:** Saving factory calibration data
- **GPIO1:** Output
- **GPIO2:** Input / output



VD6283TX | Sensing operation



Need actual data 1st data available

VD6283TX | use case #1

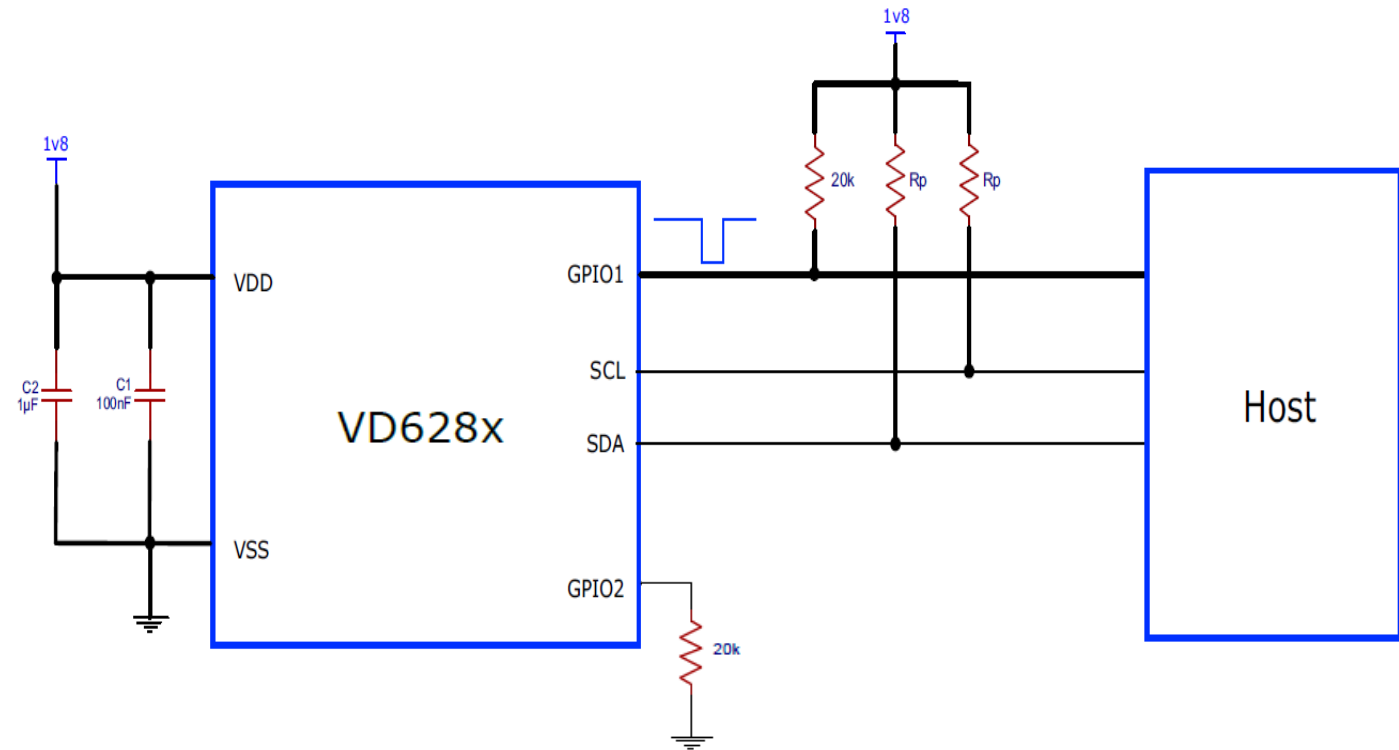
ALS Only

Flicker operation

- No application

ALS operation

- DC values (R,G,B, UVA, IR, Clear) are output through I2C.
- GPIO1 is used to be interrupt pin.



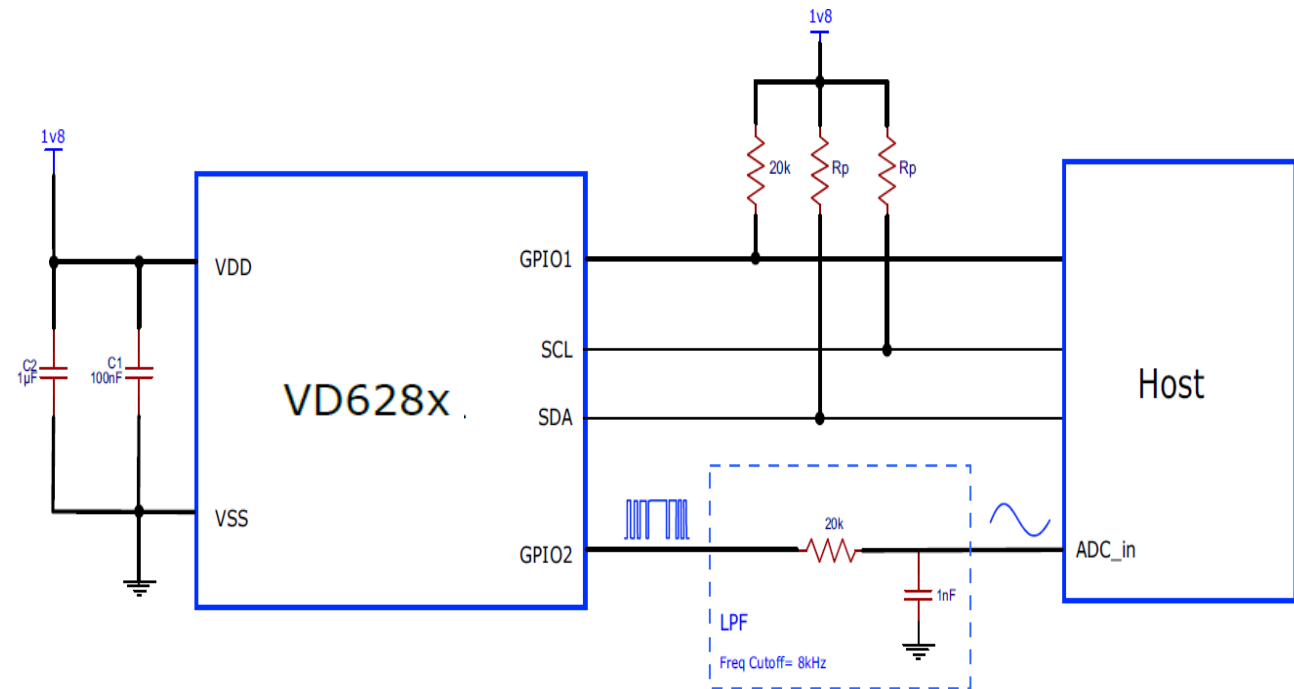
VD6283TX | use case #2 ALS & AC Flicker Output

Flicker operation

- GPIO2 pin is used as 'Output'.
- Flicker frequency is output through an RC filter, and the final signal is analogue. A simple FFT (Fast Fourier Transform) can provide AC light multi-tone harmonics (through host computation)
- VD6283 is using its internal clock (10MHz) for sensing operation
- Flicker frequency can be done on one channel over 6 channels

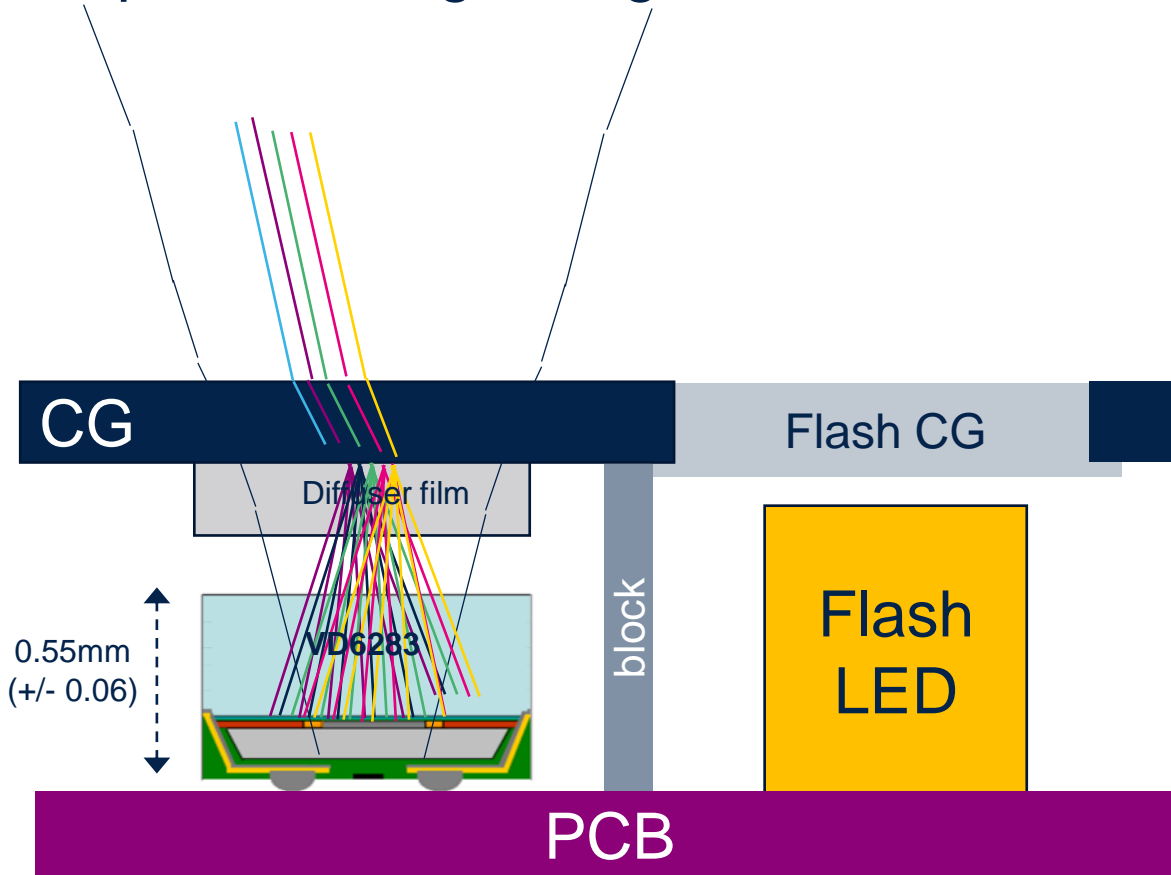
ALS operation

- DC values (R,G,B, UVA, IR, Clear) are output through I2C.
- GPIO1 is a free pin, that can be used to manage interrupts and handshake with the host.



VD6283TX | Example mechanical integration

Example: stacking with glass and diffuser film



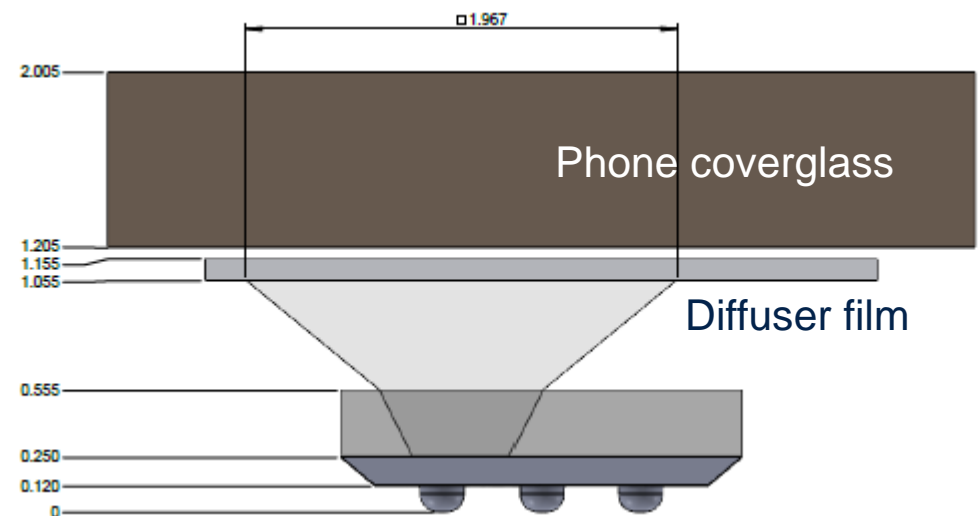
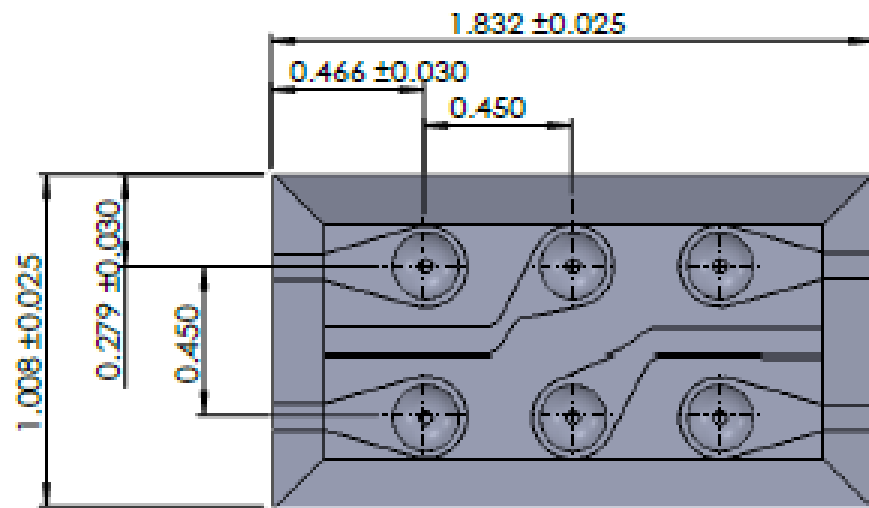
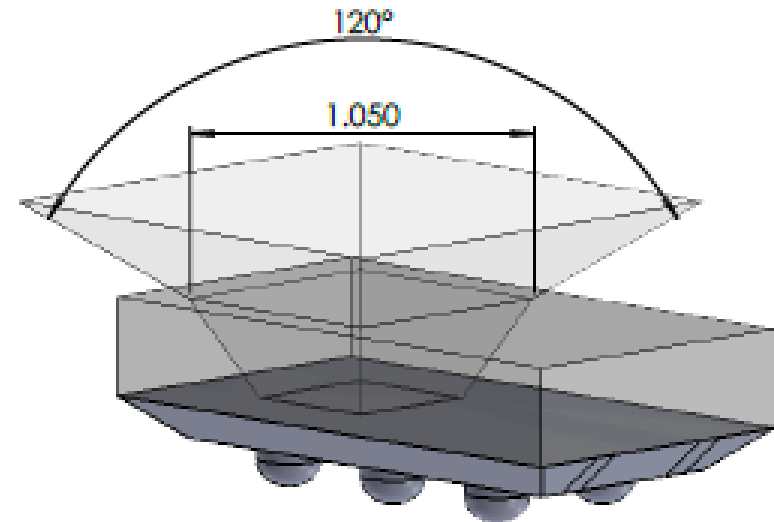
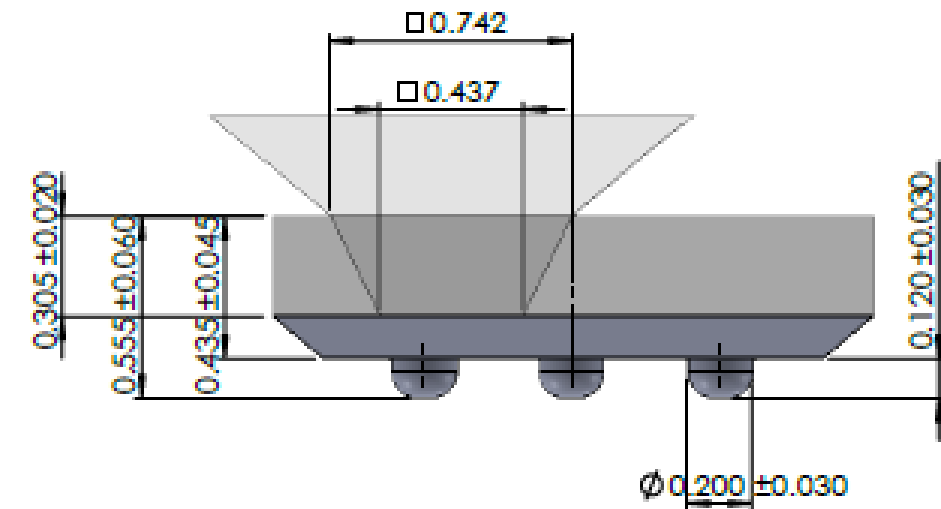
- Diffuser glued above the ALS
- ST can provide a reference film (prototype, spec, contact) in China.
- Benefit :
 - With attenuation factor, wider dynamic (100kLux and more)
 - Light scattering : enhanced performance in angle

In application note AN5638

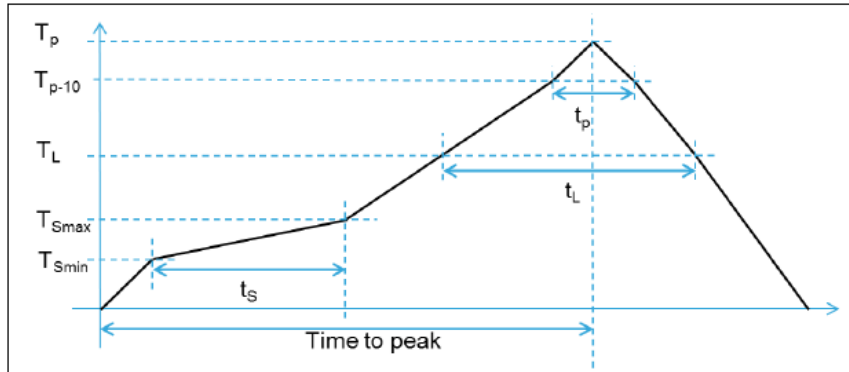
Cover glass recommendation

The Illuminance (Lux) value is directly related to the amount of light received by the sensor. A cover glass on top of the sensor will reduce the amount of light received. Therefore, the Lux calculation will be biased. ST recommends a cover glass as neutral as possible on RGB channels spectrum, and above 20 % transmittance, to avoid any CCT degradation.

VD6283TX | FOV 120° example



VD6283TX | Recommended soldering profile



Note: The component should be limited to a maximum of 3 passes through this solder profile.

- **VD628X** is compliant with **Jedec J-STD-020E** specification
 - (Moisture/Reflow Sensitivity Classification for Non-hermetic Surface Mount Device)
 - **Up to 3x times reflow** (260°C max peak)
 - Compatible with interposer
- Customers must perform their own soldering trials for sanity check (own material, own soldering past, own tool, own oven and temperature profile, ...)

VD6283 (Rainbow) soldering profile

Parameters	Recommended	Maximum	Units
Minimum temperature (TS min)	100	150	°C
Maximum temperature (TS max)	180	200	°C
Time t_s ($T_{S\ min}$ to $T_{S\ max}$)	80	60-120	seconds
Temperature (T_L)	180	217	°C
Time (t_L)	110	60-150	seconds
Ramp up	+1.5	+3	°C/second
Temperature (T_{p-10})	230	250	°C
Time (t_{p-10})	-	30	seconds
Ramp up	+0.5	+3	°C/second
Peak temperature (T_p)	240	260	°C
Time to peak	220	480	seconds
Ramp down (peak to T_L)	-2	-6	°C/second

VD6283TX

GUI introduction



VD6283TX | Hardware

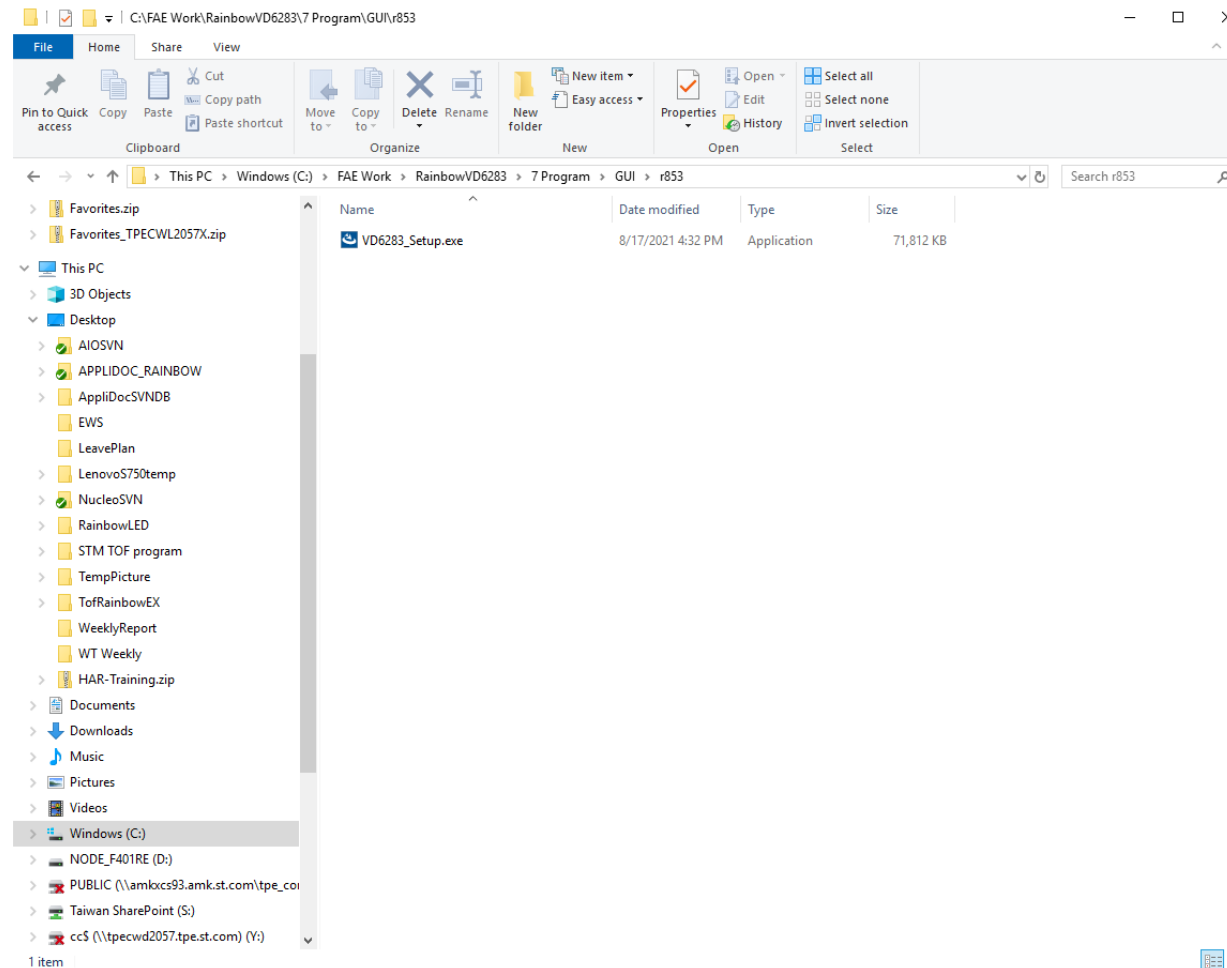


Nucleo EVK
(VD6283TX)
P-NUCLEO-6283A1

→ for customer evaluation

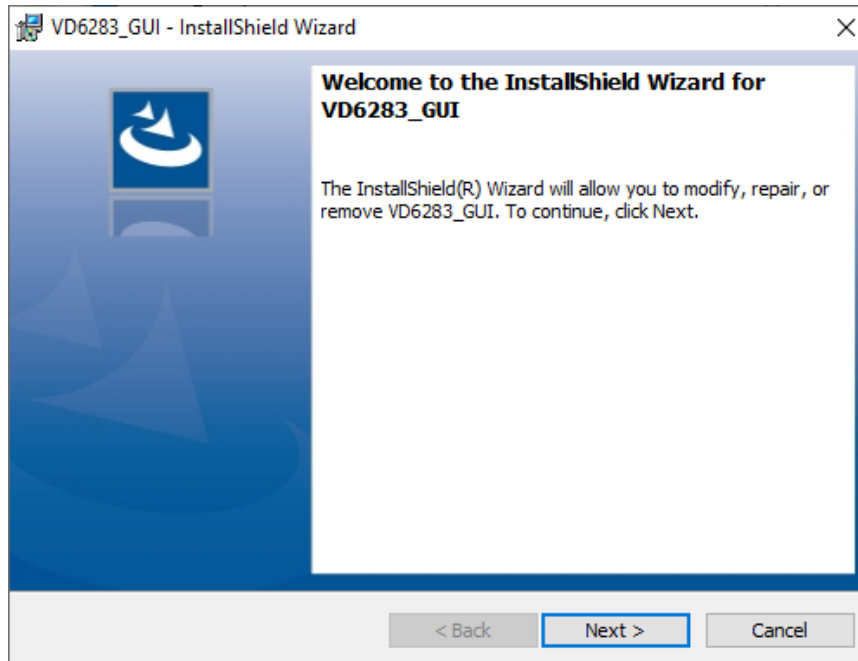
VD6283TX | SW Installation (1/3)

- Launch VD6283.exe (Same as VD6283TX)

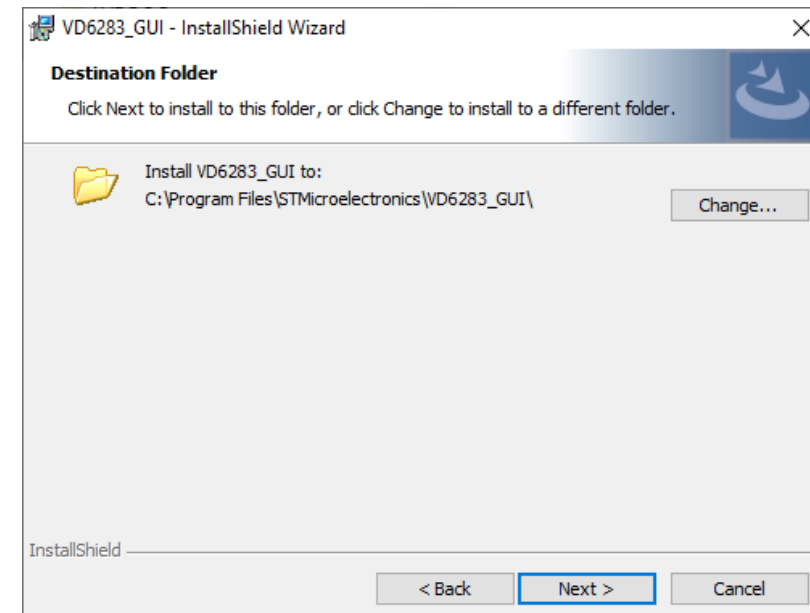


VD6283TX | SW Install (2/3)

- Click “Next” to start

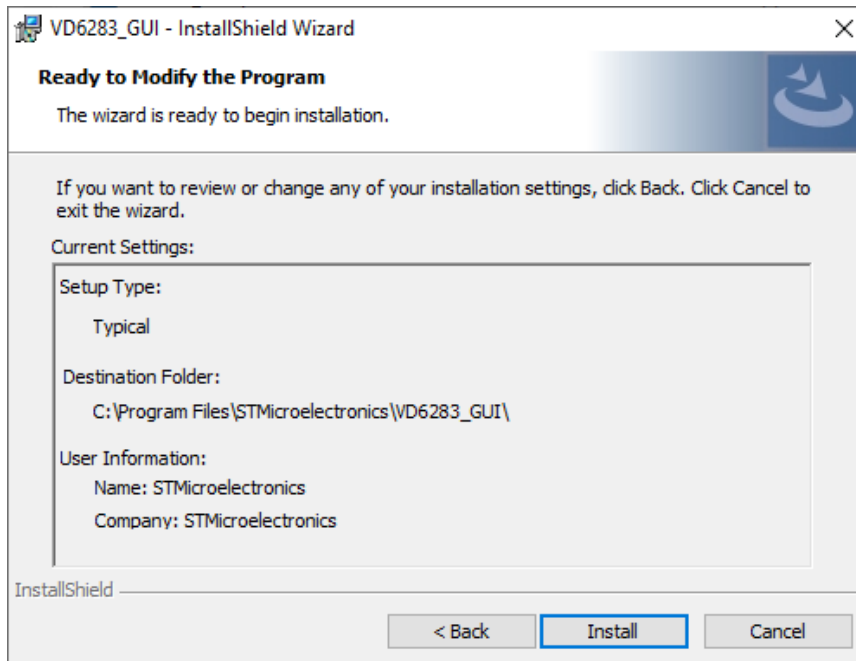


- Change Destination Folder if you want
- Otherwise: Click “Next”

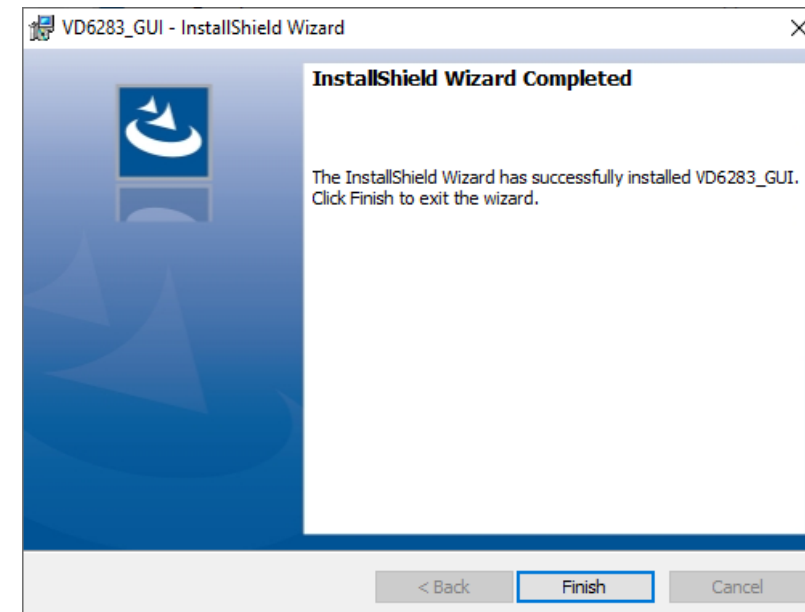


VD6283TX | SW Install (3/3)

- Click “Install” to start

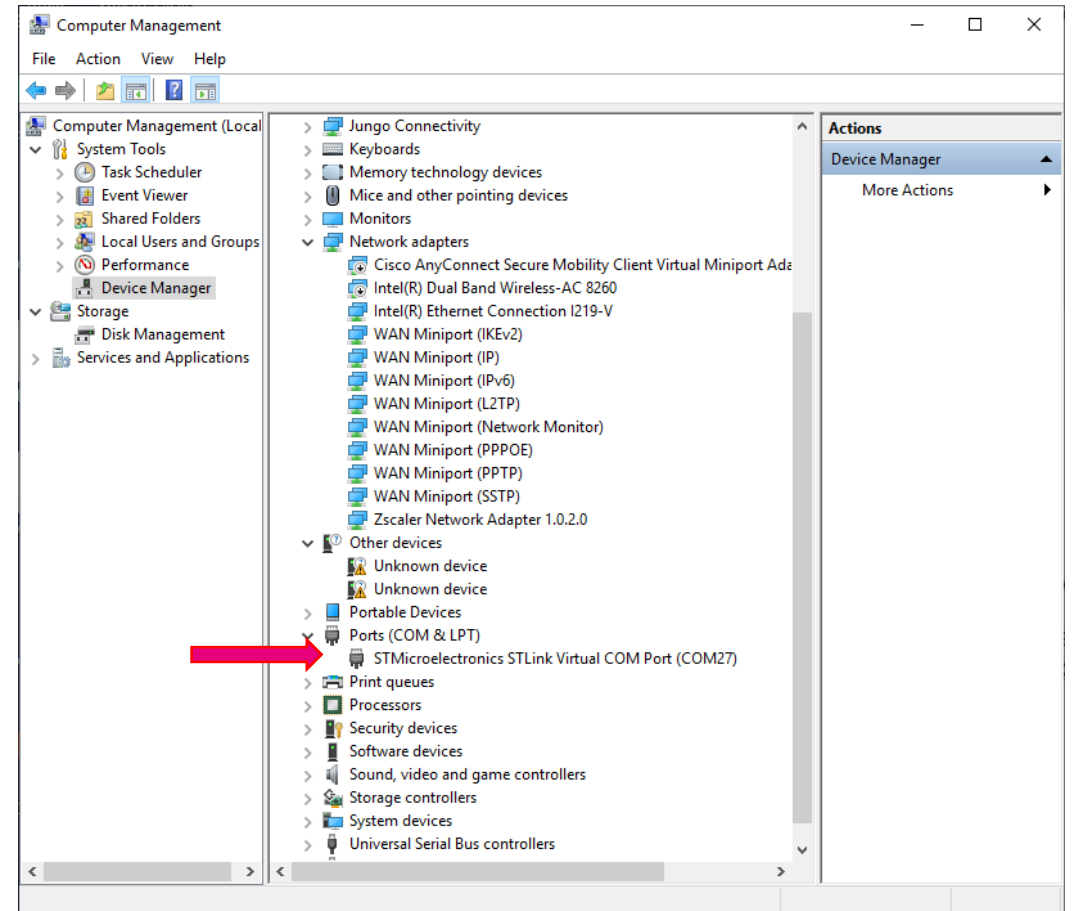


- Click “Finish” to close the installation process
- Shortcut now available on your Desktop



VD6283TX | Device Info

- Plug USB cable between PC and EVK
- At the 1st connection, PC will detect and automatically install the Nucleo board
- You can then see STLink on Device Manager Port COMs

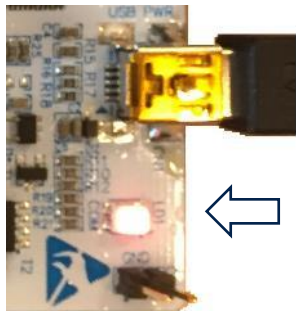


VD6283TX | Rainbow GUI – Flash FW

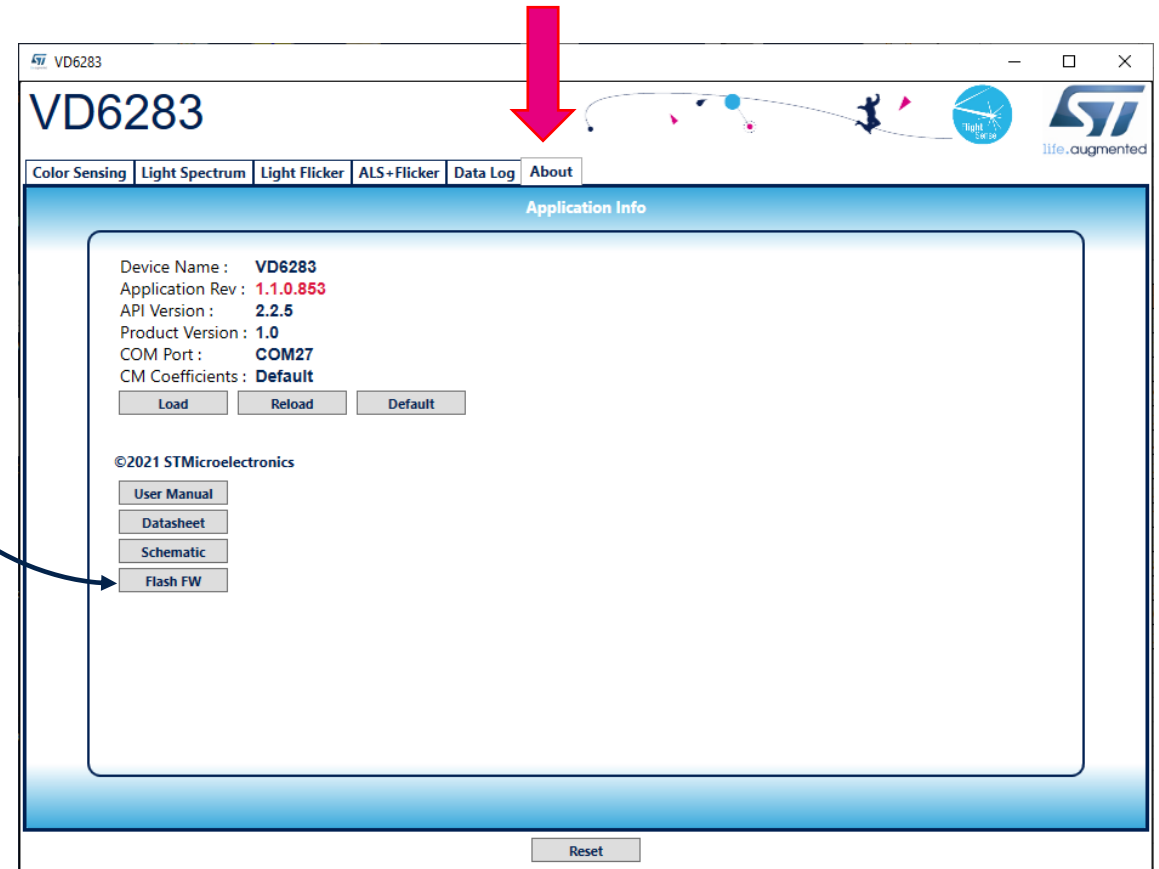


- Open the GUI with Shortcut available on Desktop

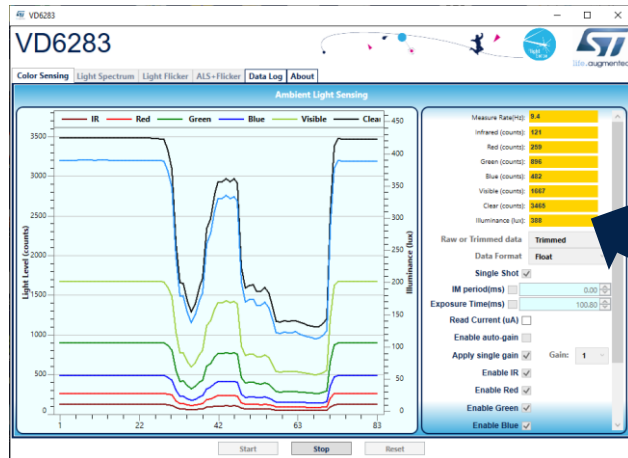
- Open “About” tab
- Choose the FW you want to load:
 - Click « Flash ALS FW »
 - or
 - Click « Flash Flicker FW »
- During Flash of FW, the Status LED is blinking



Status
LED



VD6283TX | GUI

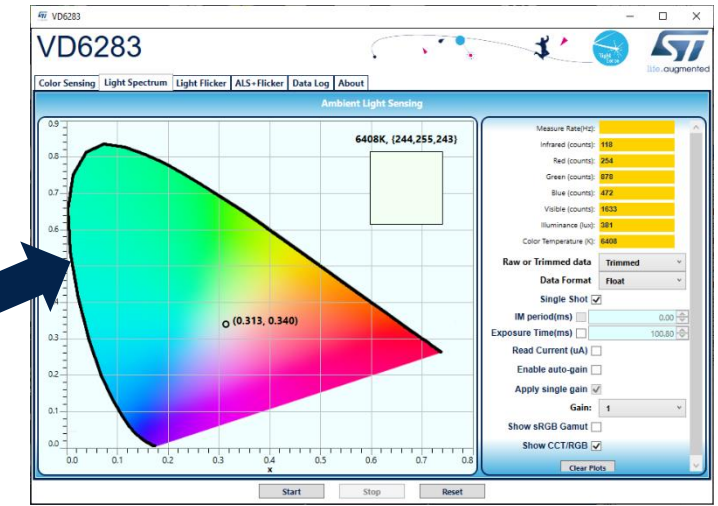


ALS

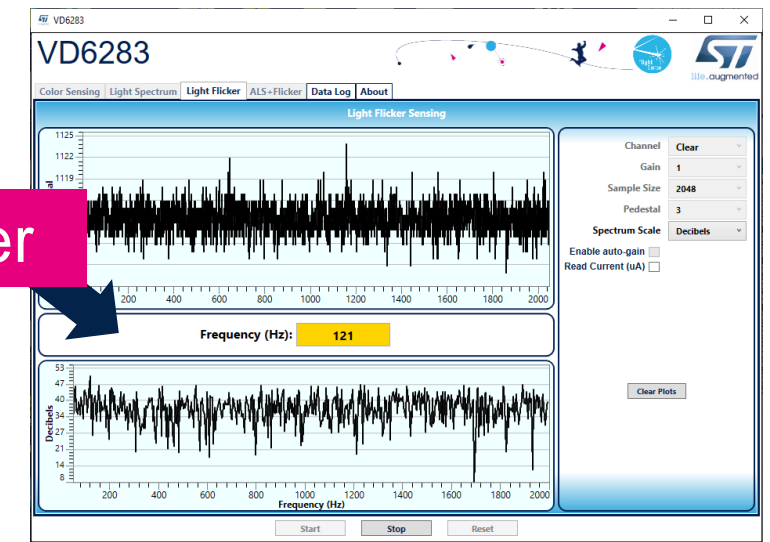
Device Name : VD6283
Application Rev : 1.1.0.853
API Version : 2.2.5
Product Version : 1.0
COM Port : COM27
CM Coefficients : Default

©2021 STMicroelectronics
User Manual
Datasheet
Schematic
Flash FW

CCT



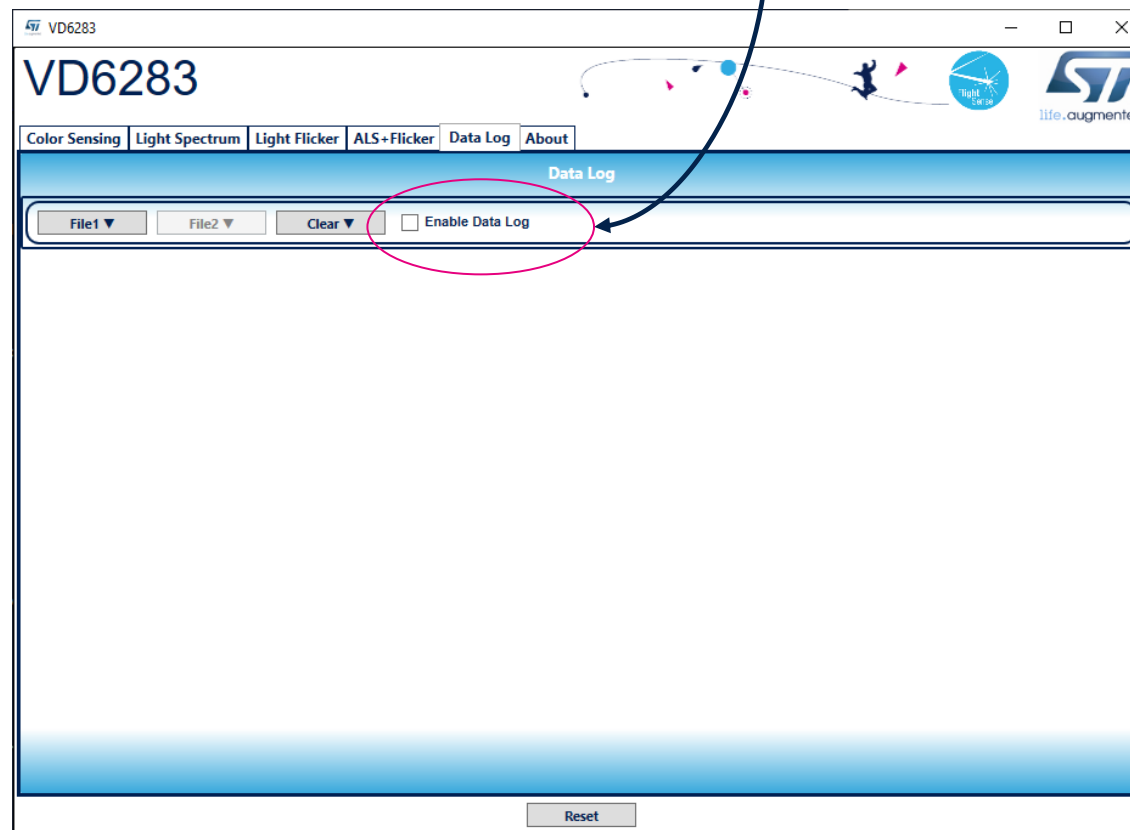
Flicker



VD6283TX | Graphic Log

- Data Log tab

- Allows obtained data from runs to be stored in .csv files
- Data from previous runs can then be loaded and compared
- Enable data log selection before start a run.



VD6283TX | Format of data log

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	count	error	timestamp	dataLogCount	infrared	red	visible	blue	green	clear	infraredRaw	redRaw	visibleRaw	blueRaw	greenRaw	clearRaw	x	y	CCT
2	296	0	147	0	173.0508	292.7773	1883.914	541.9375	999.1914	0	158.2188	323.0664	1883.914	541.9375	913.5469	0	0.313193	0.339569	6408.397
3	297	0	322	1	173.2891	292.9766	1885.316	542.4922	1000.191	0	158.4375	323.2852	1885.316	542.4922	914.4609	0	0.313168	0.33956	6409.751
4	298	0	461	2	174.1523	293.5117	1889.5	543.6211	1002.094	0	159.2266	323.8789	1889.5	543.6211	916.2031	0	0.313146	0.339543	6410.958
5	299	0	586	3	174.3711	294.0781	1891.785	544.0898	1003.328	0	159.4258	324.5039	1891.785	544.0898	917.332	0	0.313231	0.33959	6406.372
6	300	0	711	4	174.3086	294.0625	1891.602	543.9766	1003.113	0	159.3711	324.4844	1891.602	543.9766	917.1328	0	0.313243	0.339594	6405.779
7	301	0	832	5	173.9453	293.9141	1889.734	543.4531	1002.25	0	159.0391	324.3203	1889.734	543.4531	916.3438	0	0.313279	0.33961	6403.882
8	302	0	956	6	173.7188	293.5469	1888.371	543	1001.449	0	158.832	323.918	1888.371	543	915.6133	0	0.313248	0.339603	6405.446
9	303	0	1078	7	173.7578	293.3359	1888.031	542.9492	1001.199	0	158.8672	323.6836	1888.031	542.9492	915.3828	0	0.313199	0.339579	6408.06
10	304	0	1198	8	173.957	293.5234	1888.98	543.3477	1001.91	0	159.0469	323.8906	1888.98	543.3477	916.0352	0	0.313192	0.339575	6408.455
11	305	0	1320	9	174.0117	293.7656	1889.957	543.6797	1002.348	0	159.0977	324.1563	1889.957	543.6797	916.4336	0	0.313204	0.33957	6407.848
12	306	0	1443	10	173.9531	293.8242	1890.605	543.8828	1002.766	0	159.043	324.2227	1890.605	543.8828	916.8164	0	0.313192	0.339568	6408.466
13	307	0	1567	11	173.9609	293.8789	1890.406	543.6836	1002.586	0	159.0508	324.2813	1890.406	543.6836	916.6523	0	0.313237	0.339592	6406.095
14	308	0	1692	12	173.957	293.8867	1890.535	543.8633	1003.027	0	159.0469	324.2891	1890.535	543.8633	917.0547	0	0.313216	0.339592	6407.131
15	309	0	1812	13	173.9766	293.9609	1890.648	543.9063	1003.156	0	159.0664	324.3711	1890.648	543.9063	917.1719	0	0.31323	0.339599	6406.398
16	310	0	1940	14	173.8984	294.0664	1890.906	543.9336	1003.258	0	158.9961	324.4883	1890.906	543.9336	917.2656	0	0.313254	0.339609	6405.143
17	311	0	2063	15	173.8633	294.1289	1891.473	544.0664	1003.41	0	158.9609	324.5586	1891.473	544.0664	917.4063	0	0.31325	0.339603	6405.381
18	312	0	2186	16	173.793	294.2148	1891.355	543.9336	1003.281	0	158.8984	324.6523	1891.355	543.9336	917.2891	0	0.313291	0.339622	6403.163
19	313	0	2307	17	173.8711	294.1484	1891.465	544.0313	1003.492	0	158.9688	324.5781	1891.465	544.0313	917.4805	0	0.313262	0.339615	6404.69
20	314	0	2430	18	173.8242	294.0352	1891.152	543.9648	1002.98	0	158.9258	324.4531	1891.152	543.9648	917.0117	0	0.313235	0.339585	6406.195
21	315	0	2551	19	173.875	293.9492	1890.844	543.8164	1003.133	0	158.9727	324.3594	1890.844	543.8164	917.1523	0	0.313241	0.339611	6405.736
22	316	0	2673	20	173.7578	293.875	1890.301	543.8711	1002.742	0	158.8672	324.2773	1890.301	543.8711	916.793	0	0.313207	0.339573	6407.717
23	317	0	2797	21	173.7461	293.9219	1890.355	543.9258	1002.707	0	158.8555	324.3281	1890.355	543.9258	916.7617	0	0.313209	0.339566	6407.66
24	318	0	2926	22	173.8672	294.1523	1891.23	544.1211	1003.129	0	158.9648	324.5859	1891.23	544.1211	917.1484	0	0.313241	0.339579	6405.94
25	319	0	3047	23	173.8516	294	1891.398	543.9258	1003.273	0	158.9531	324.4141	1891.398	543.9258	917.2813	0	0.313238	0.339607	6405.922
26	320	0	3173	24	173.6914	293.9844	1890.914	543.8711	1003.055	0	158.8047	324.3984	1890.914	543.8711	917.082	0	0.31324	0.3396	6405.887
27	321	0	3299	25	173.5273	294.1406	1891.027	544.1211	1003.297	0	158.6563	324.5703	1891.027	544.1211	917.3008	0	0.313241	0.339588	6405.883
28	322	0	3426	26	173.3477	294.0391	1891.152	543.9844	1003.465	0	158.4922	324.457	1891.152	543.9844	917.457	0	0.313242	0.339612	6405.721
29	323	0	3550	27	173.0703	294.1914	1891.188	544.1172	1003.504	0	158.2383	324.6289	1891.188	544.1172	917.4922	0	0.313258	0.339606	6404.92
30	324	0	3673	28	172.9609	294.2617	1892.391	544.4688	1004.406	0	158.1367	324.7031	1892.391	544.4688	918.3164	0	0.313233	0.339612	6406.175

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