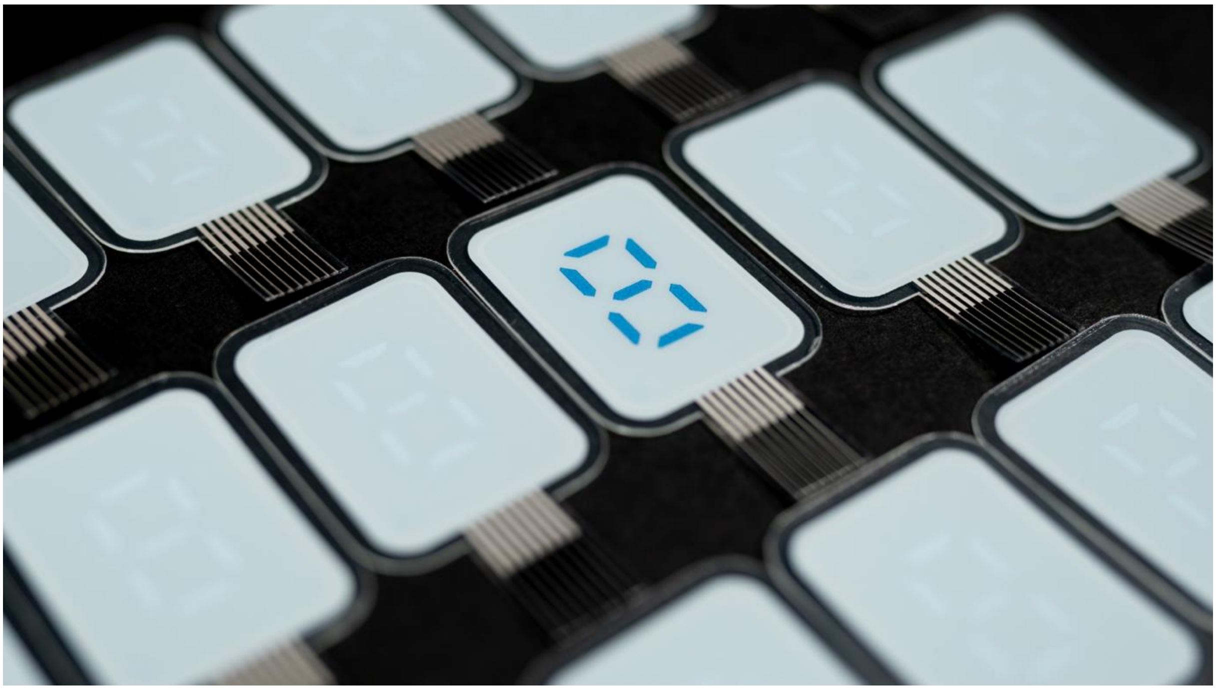
Ynvisible E-Paper Display

Gen. 2

Datasheet



***Note:** If you purchased displays before February 28th 2022, please follow [this datasheet] instead.*

Table of Contents

Version History

Version	Date	Description	Changed by
1.0	2022-02-28	First issue	Philip Holgersson
1.1	2022-03-07	Added circuits	Philip Holgersson
1.2	2022-02-22	Added active Driving and Changes in Circuits and Driving Scheme	Milton Fernandes

Notes

Ynvisible's displays shall not be used for equipment that requires extremely high reliability, such as nuclear power control equipment, medical equipment for life support, military and space applications, or aerospace equipment.

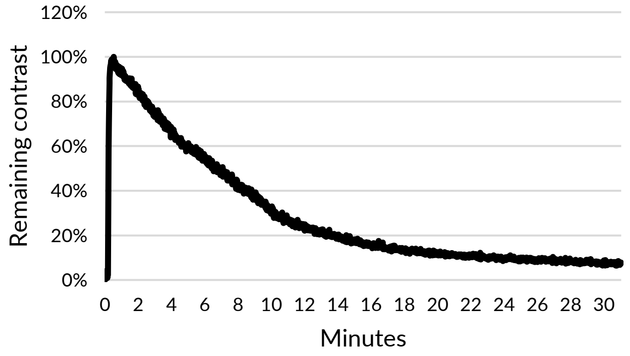
1. Introduction

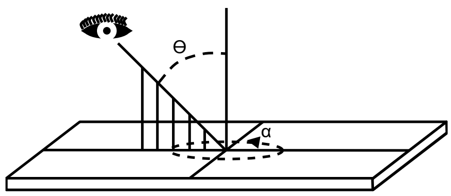
This datasheet covers generalized information about Ynvisible's e-paper display technology and is not specific to any display design or part number. Ynvisible's printed e-paper is an electrochromic reflective technology and has a very low angle dependency. It is ultra-low power and features semi-bistability, which means that the display mainly consumes power during display switches but requires a short refresh pulse. The features are summarized in the list below:

A. Ultra-low-power
B. Low operating voltage
C. Reflective
D. No viewing angle dependency
E. Long refresh time
F. Flexible
G. Environmentally friendly

2. Optical Characteristics

Parameter	Test condition	Min	Typical	Max	Unit	Note
Reflectance	Bright state, 25°C	38%	40%	45%	Y-value	
Reflectance	Dark state, 25°C	8%	12%	14%	Y-value	
Viewing angle (θ_v)			89		°	
Refresh interval	25°C, (1) Time to 80% remaining contrast	n.a	2,5		Minutes	





3. Mechanical Characteristics

Parameter	Typical	Unit
Thickness	0,35	mm
Weight	0,04	g/cm^2
Bend radius	10	mm

4. Electrical Characteristics

Parameter	Test Condition	Min	Typical	Max	Unit	Notes
Energy consumption (switch)	10 mm^2 segment, 25°C, 30-50% RH		1		mJ/cm^2	1,5V driving voltage, From OFF to ON
Supply current (average)	10 mm^2 segment, 25°C, 30-50% RH		1,1		$\mu A/cm^2$	1,5V driving voltage, Steady state (ON)
Segment peak current	10 mm^2 segment, 25°C, 30-50% RH		0,4		mA	1,5V driving voltage, From OFF to ON
Recommended ON voltage	10 mm^2 segment, 25°C, 30-50% RH	1	1.5	1,5	V	
Recommended OFF voltage	10 mm^2 segment, 25°C, 30-50% RH	0	-1,5	-1,5	V	

5. Power Consumption

Parameter	Test Condition	Typical	Unit	Notes
Average power consumption	25°C, 30-50% RH	1,67	$\mu W/cm^2$	Steady state, all segments ON
Average power consumption	25°C, 30-50% RH	1,52	$\mu W/cm^2$	Steady state, all segments OFF
Average power (10 switches)	25°C, 30-50% RH	1,78	$\mu W/cm^2$	All segments changing state 10 times per day
Average power (100 switches)	25°C, 30-50% RH	2,82	$\mu W/cm^2$	All segments changing state 100 times per day
Average power (1000 switches)	25°C, 30-50% RH	13,24	$\mu W/cm^2$	All segments changing state 1000 times per day

6. Environmental

Parameter	Test Condition	Min	Max	Unit	Notes
Operating temperature	25°C, 30-50% RH	-20	60	°C	Internal test
Storage temperature	30-50% RH	-40	60	°C	Internal test

6.1 UV Exposure

The display intended for indoor applications; extended UV exposure may cause degradation. For outdoor applications a UV protection film testing is required.

7. Lifetime

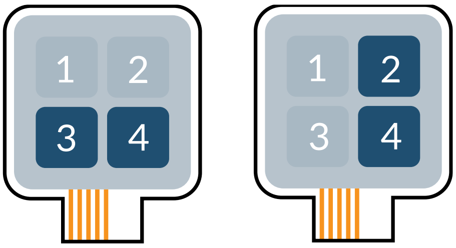
Parameter	Test Condition	Min	Typical	Max	Unit	Method	Notes
Switch cycles	25°C, 30-50% RH	300 000	1 000 000	-	Switch cycles	Internal	ON/OFF cycles [1]

8. Recommended Driving Scheme

Fundamentally the displays are very straightforward to drive. A positive voltage (in reference to the counter electrode) turns ON the display segment, while a negative voltage turns OFF the segment. A higher voltage level enables a faster switching speed, while a lower voltage enables a longer lifetime. Typically, a good tradeoff between lifetime and switch speed is to use ±1,5V across the segment. Higher voltage is optional for devices with shorter lifetime requirements. Turn OFF voltage should typically be kept the same as turn ON voltage (but with the opposite polarity) Below follows a few different driving schemes suggestions.

Definition of the conventions used in the following driving schemes:

Convention	Segment nr. in figure	Definition
COM	-	Common electrode
SEG (OFF – OFF)	1	Segments that should be kept in OFF state
SEG (OFF – ON)	2	Segments that should turn ON
SEG (ON – OFF)	3	Segments that should turn OFF
SEG (ON – ON)	4	Segment that should be kept in ON state

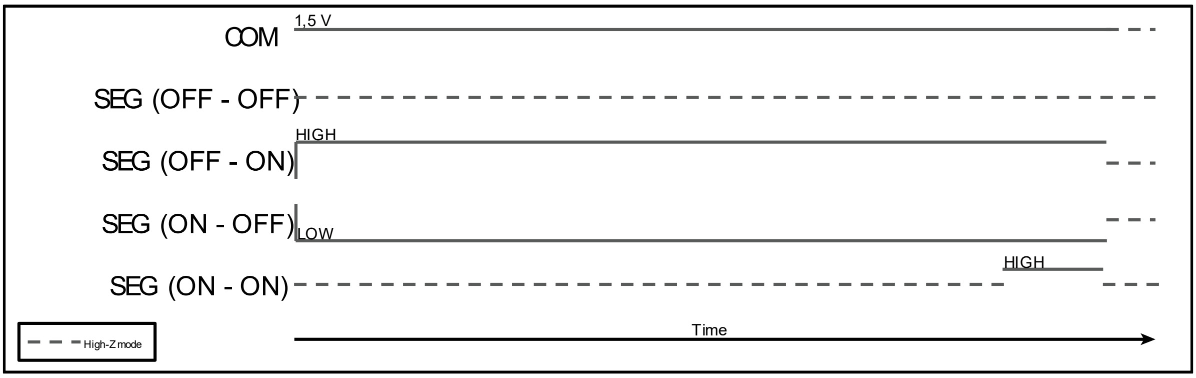


Before update *After update*

8.1 Passive Driving

This driving method is recommended for applications that need a reduced number of switches or single use applications.
This driving updates the display in one single step. The segments are turned ON and OFF at the same time. This is enabled by setting the counter electrode to a voltage in between LOW and HIGH, typically ±1,5V for a 3V system, but could also be for example ±1V for a 2V system. In this way a positive and a negative voltage can be applied on the respective segment simultaneously. A shorter refresh pulse is required on the segments that should be kept in ON state. The sequence end with setting all signals to High-Z to maintain the state.

[1] The total number of times the display can be turned on and off without losing more than 20% of the initial contrast.



8.2 Active Driving

This driving method is recommended for applications that need a to have a high lifetime or perform a high number of switches.

This driving approach is centered around the definition of two voltage ranges that corresponds to a colored ("ON") and bleached ("OFF") state of the segment. Given these boundary conditions, the driver's task is to make sure that all segments are within the colored voltage range. Exactly what the ranges should be depends on the desired contrast, but good starting values are:

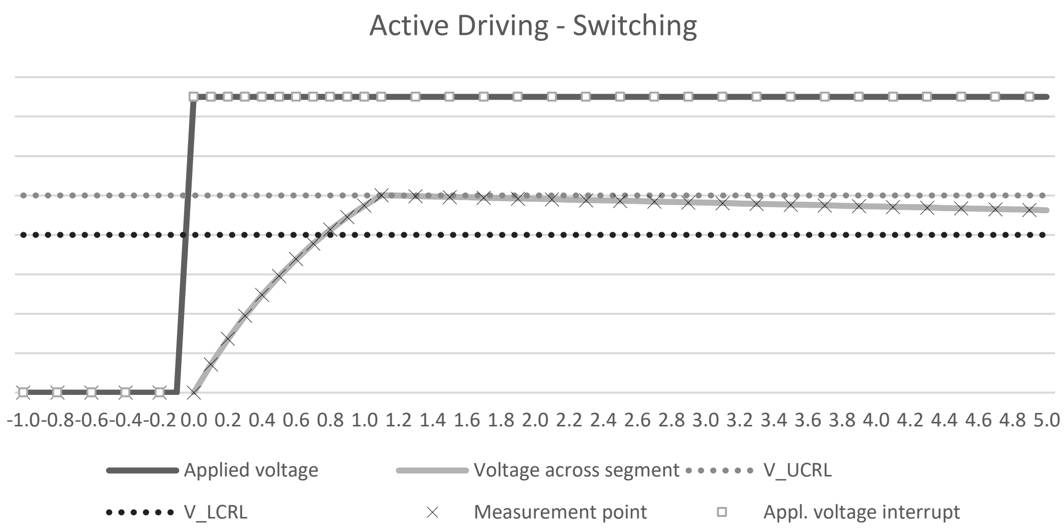
Variable	Example voltage (V)
V_{LCRL} (Lower Colored Range Limit)	0.7
V_{UCRL} (Upper Colored Range Limit)	0.9
V_{LBRL} (Lower Bleached Range Limit)	-0.6
V_{UBRL} (Upper Bleached Range Limit)	-0.4

8.2.1 Coloring one segment

The coloring of one segment is done with the following sequence (Appendix Chart 1):

1. Measure OCP
2. If OCP is below upper colored range limit
    a. Apply positive (≈1.5V) voltage for X ms
    b. Back to 1
3. If OCP is above upper colored range limit
    a. Switch is done

Example:

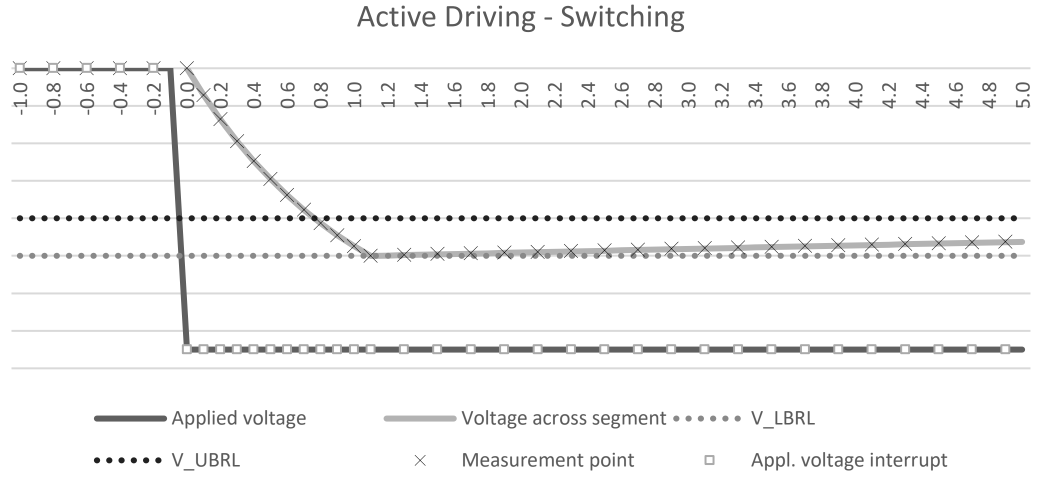


8.2.2 Bleaching one segment

The bleaching of one segment is done with the following sequence (Appendix Chart 2):

1. Measure OCP
2. If OCP is above lower bleached range limit
    a. Apply negative voltage (≈-1.5V) for X ms
    b. Back to 1
3. If OCP is below lower bleached region limit
    a. Switch is done

Example:



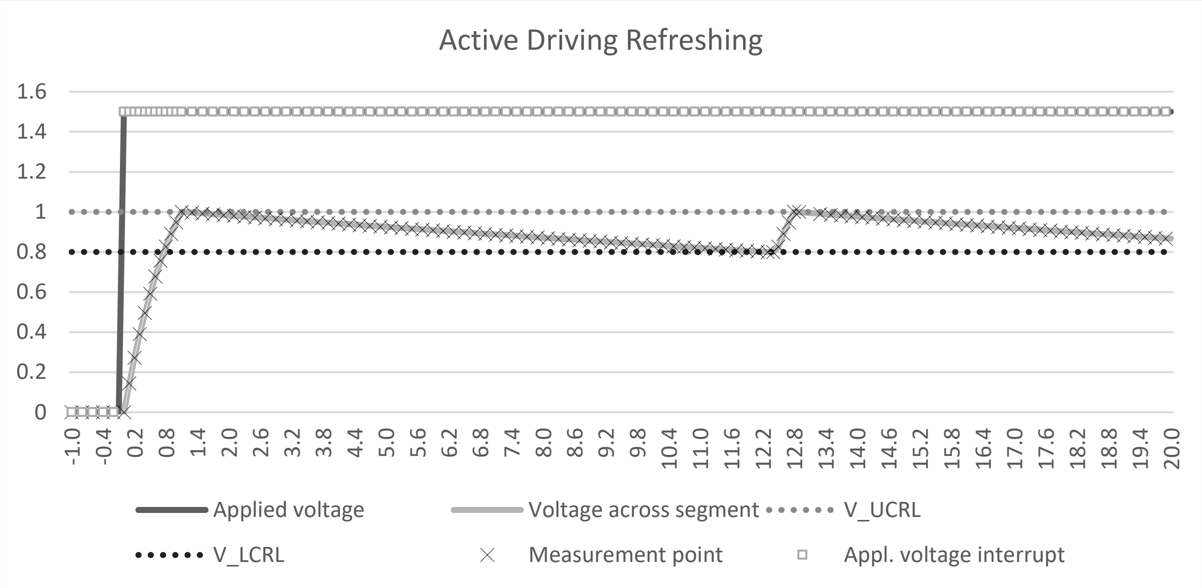
During the switch and refresh, the applied voltage is interrupted for short periods (marked by the squares) and the voltage limits (TH_RED, TH_RED_R) are only examples. This is a simulated graph, in reality it looks less perfect, but the concept is the same.

8.2.3 Refreshing one segment – Colored state

The refresh (in between switches to maintain the state) of one segment is done with the following sequence (Appendix Chart 3):

1. Measure OCP
2. If OCP is above lower colored voltage range limit
   a. Wait for X seconds
   b. Back to 1
3. If OCP is below lower colored voltage range limit
   a. Color segment in accordance with “2.2 Coloring one segment”

Example:



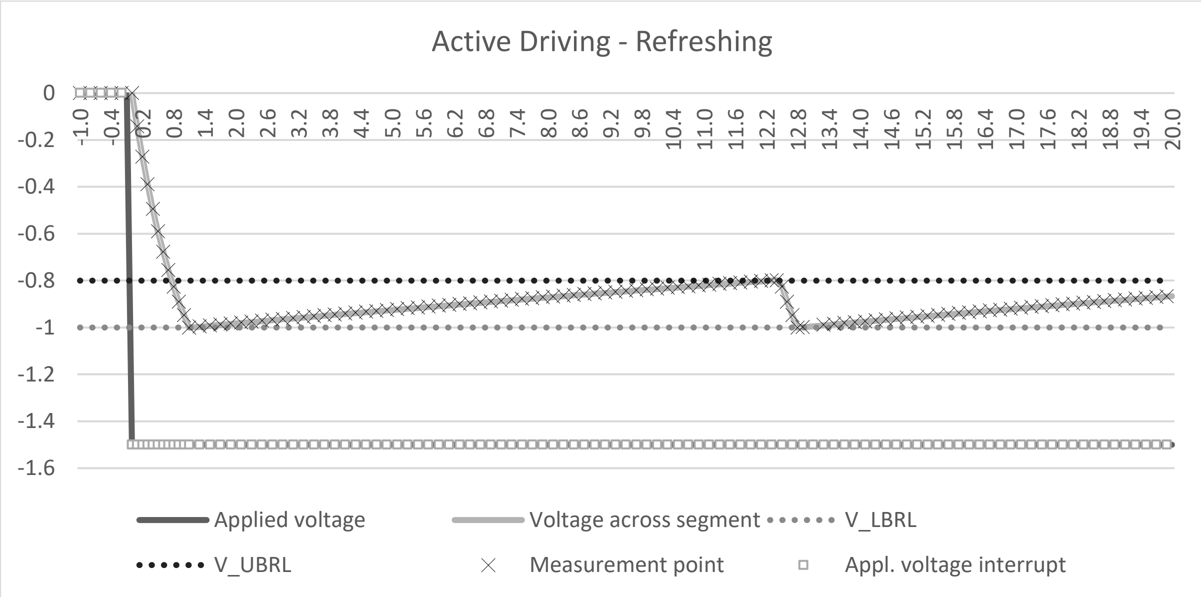
During the switch and refresh, the applied voltage is interrupted for short periods (marked by the squares) and the voltage limits (TH_RED, TH_RED_R) are only examples. This is a simulated graph, in reality it looks less perfect, but the concept is the same.

8.2.4 Refreshing one segment – Bleached state

The refresh (in between switches to maintain the state) of one segment is done with the following sequence (Appendix Chart 4):

1. Measure OCP
2. If OCP is below upper colored voltage range limit
   a. Wait for X seconds
   b. Back to 1
3. If OCP is above upper colored voltage range limit
   a. Color segment in accordance with “2.3 Bleaching one segment”

Example:



During the switch and refresh, the applied voltage is interrupted for short periods (marked by the squares) and the voltage limits (TH_RED, TH_RED_R) are only examples. This is a simulated graph, in reality it looks less perfect, but the concept is the same.

8.2.5 Driving voltage and OCP voltage

It is crucial to understand that driving voltage and OCP voltage are two different things. The driving voltage is the voltage we apply on the segment (typically 1,5V) while the OCP voltage is the voltage caused by the charge stored in the segment itself.

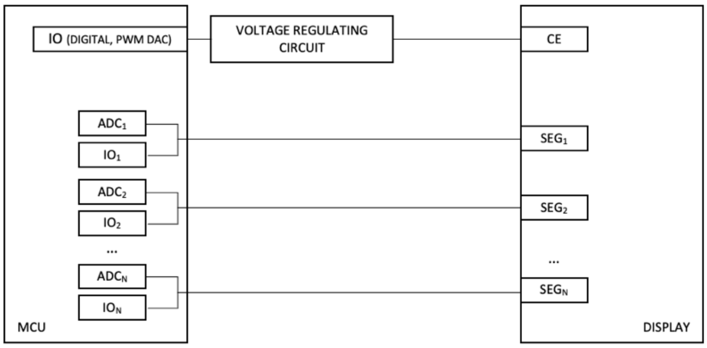
Up until now, the driving voltage has been 1.5V at the expense of a slower switching speed it can be reduced. A lower voltage leads to less bleeding effect and a longer lifetime of the display.

9 Hardware implementations for active driving

Measuring the OCP across a segment is typically facilitated with a built in AD converter. The ADC measurement can either take place on the work electrode or the common electrode. Typically, the number of ADC ports are limited making the measurement on the counter electrode a better option. During normal circumstances the measurement of each segment need to take place in sequence. To measure the OCP across one segment all work electrodes but the measured one should be set in High-Z mode.

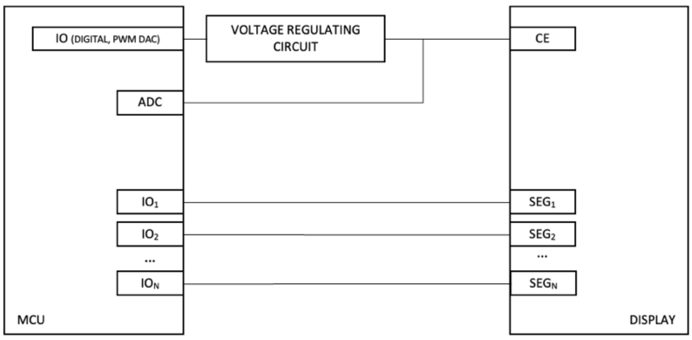
9.1 ADC measurements on work electrodes

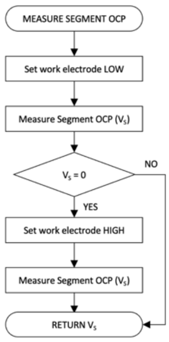
The graphs below display a suggested hardware implementation with ADC measurements on the work electrodes.



9.2 ADC measurements on common electrode

The graphs below display a suggested hardware implementation with ADC measurements on the counter electrode. As can be noted this approach only requires one ADC port.





Appendix I

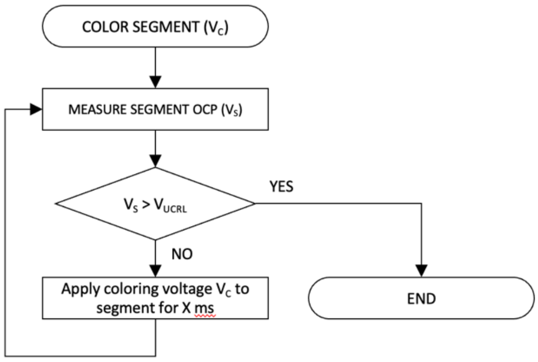


Chart 1: Coloring a segment

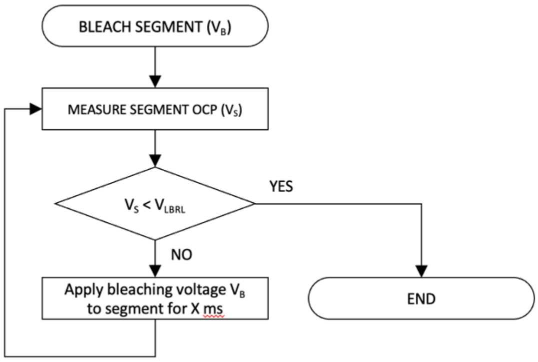


Chart 2: Bleaching a segment

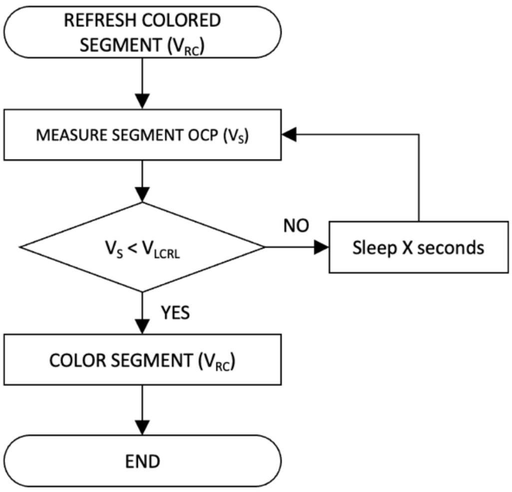


Chart 3: Refresh colored segment

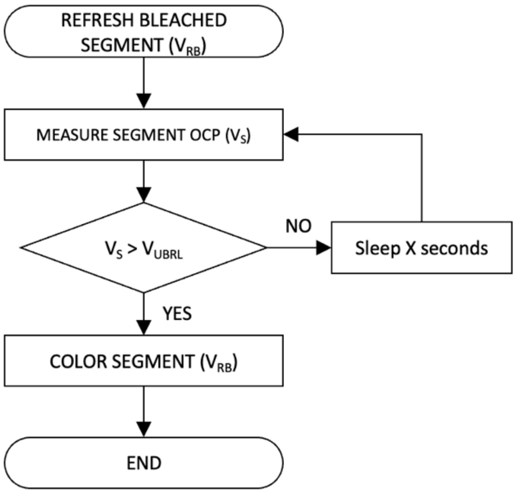


Chart 4: Refresh bleached segment