MLX91220 Application Note

Reference pin functionality and usage

Contents

1. Scope

The MLX91220's output can be used in two modes: ratiometric and non-ratiometric (also called fixed mode).

The reference pin on MLX91220 is used with non-ratiometric versions. It provides the reference voltage to which the output voltage should be compared to. Subtracting V_{ref} to V_{out} gives a signal proportional to the input current. By definition, V_{out} pin is equal to V_{ref} pin when no current is floating through the primary conductor. The equation below displays the relation between the signals $\boldsymbol{V_{out}}$, $\boldsymbol{V_{ref}}$ the sensitivity $\mathbf{S}$ in V/A and the current $\mathbf{I}$ in A when the **fixed** version is used.

$$V_{out} - V_{ref} = S.I \textbf{\textit{ (fixed mode)}}$$

In the **ratiometric** version, the output voltage is in proportion of the supply voltage V_{DD} , consequently the sensitivity S is expressed as $\%V_{DD}/A$. When no current is floating through the primary conductor $V_{out}[0A] = 50\%\ of\ V_{DD}$.

$$V_{out} - V_{out}[0A] = S.I \textbf{\textit{ (ratiometric mode)}}$$

This application note aims to describe how to use the $\boldsymbol{V_{ref}}$ pin with both sensor versions.

2. Electrical specifications

Table 1: MLX91220KDx-ABF-x electrical specifications from MLX91220_Datasheet_Rev1.0

Parameter	Symbol	Unit	Test Conditions	Specification		
				Min	Typ	Max
Reference voltage (output)	V_{ref}	V	$T_A = 35°C$	2.48	2.5	2.52
Reference voltage (input)	V_{ref}	V	$V_{DD} = 5\ V$	0.5	-	2.6
Reference internal resistance	R_{ref}	Ω	-	120	200	300
Thermal Reference Drift	ΔT_{Vref}	ppm/°C	Variation versus 25°C $V_{ref} = 2.5\ V$	-	-	±150

Table 2: MLX91221KDx-ABF-x electrical specifications from MLX91221_Datasheet_Rev1.0

Parameter	Symbol	Unit	Test Conditions	Specification		
				Min	Typ	Max
Reference voltage (output)	V_{ref}	V	$T_A = 25°C$	1.64	1.65	1.66
Reference voltage (input)	V_{ref}	V	V_{DD} = 3.14 – 3. 46 V	0.5	-	1.8
Reference internal resistance	R_{ref}	Ω	-	120	200	300
Thermal Reference Drift	ΔT_{Vref}	ppm/°C	Variation versus 25°C $V_{ref} = 1.65\ V$	-	-	±150

3. Ratiometric mode or non-ratiometric mode with internal V_{ref}

In ratiometric mode, V_{ref} is not used but the pin **should not be grounded** as this will affect the output signal. It is recommended to use a **47 nF** decoupling capacitor on the pin.

In non-ratiometric mode, V_{ref} signal can be set internally or forced externally. When the reference signal is internal, the only precaution to take is to use also a 47 nF decoupling capacitor.

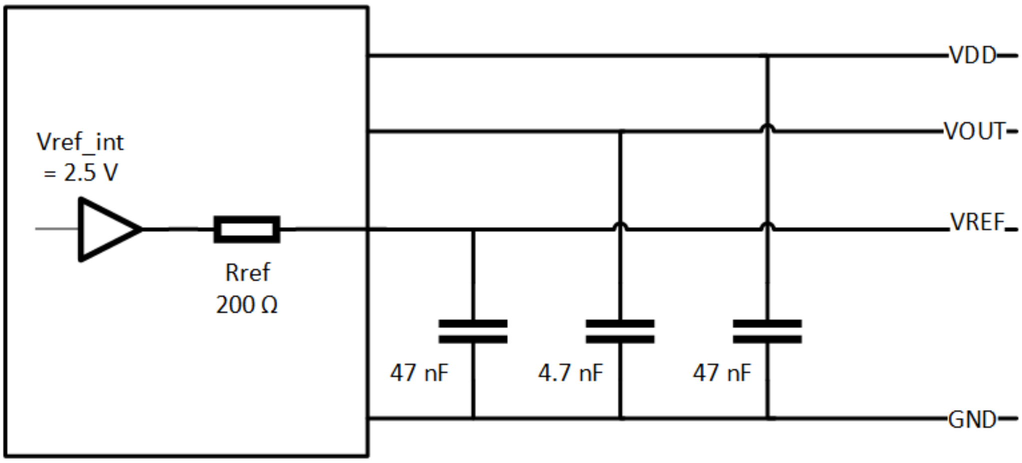

Figure 1: Vref used as output or Vref not used

4. Internal VREF

In fixed mode, one needs to measure the pin VOUT and VREF to retrieve the current. The reference voltage is provided internally and can be read directly by the microcontroller.

The reference buffer has a current source/sink limitation (source = 0.6mA and sink >> 0.6mA) that needs to be taken into account **if a resistive load is connected** to V_{ref}. Below are presented two cases: a good configuration and a bad one.

4.1. Improper configuration: External low impedance connected to VREF (Resistor divider)

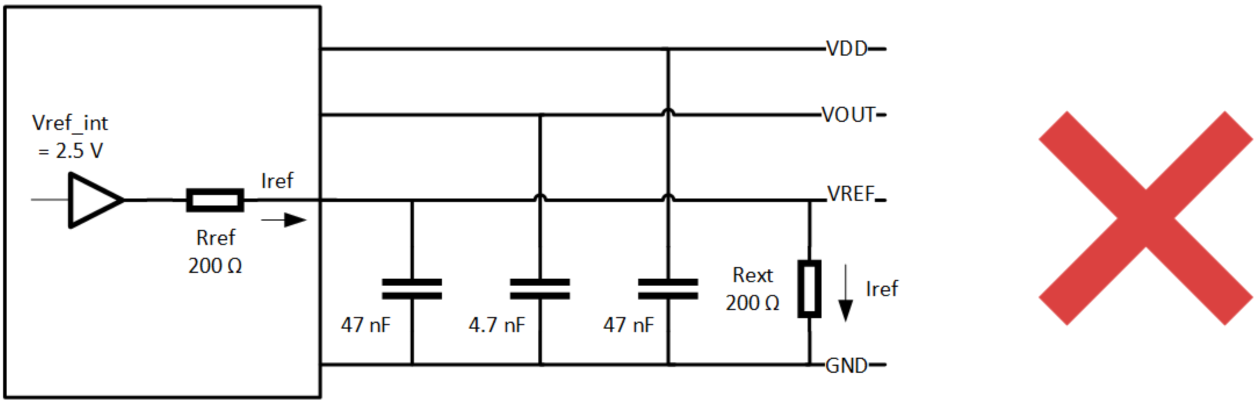

Figure 2: Low impedance configuration

VREF accuracy strongly depends on the tolerance of Rext, therefore a resistive divider is not recommended.

Ideal resistor divider (in static mode):
VREF = Vref_int * Rext / (Rref + Rext) = 1.25V
Iref = VREF / Rref = 6.25mA

Reality: MLX91220 has limitations to source and sink current IREF:
IREF_int_source_max = 0.6mA (typical value)
IREF_int_sink_max >> 0.6mA

VREF output collapses due to IREF limitation of MLX91220:
VREF = Rext * IREF_int_source_max = 0.120V

If the current Iref is below 0.6 mA, it is guaranteed to have a Vref_int = 2.5 V but the VREF will depend on the resistor value.

4.2. Recommended configuration: External high impedance connected to VREF (Resistor divider)

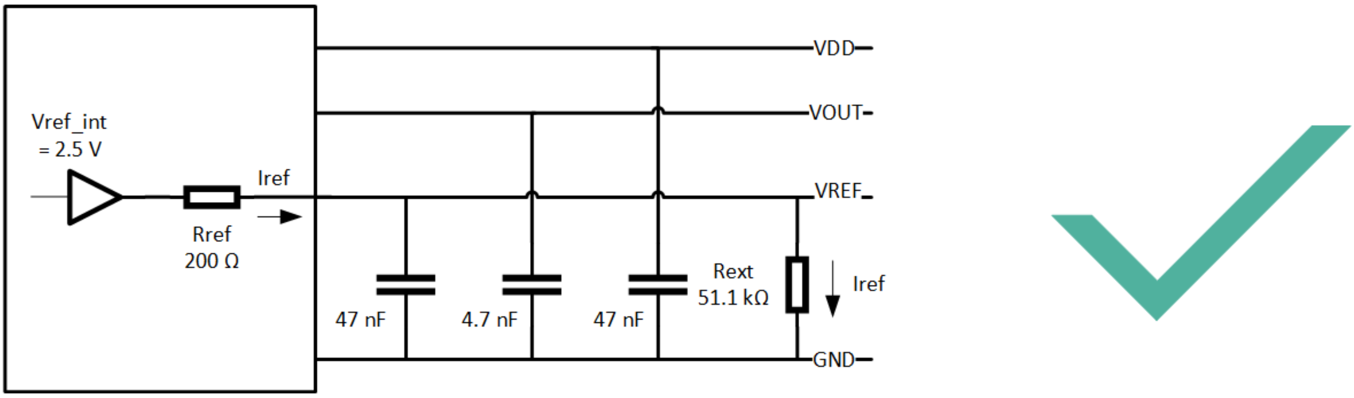

Figure 3: High impedance configuration

To avoid the current/sink limitation of the reference buffer, Iref should be < 0.6 mA. This means that $Rext > \frac{VREF}{Iref\_max} > \frac{2500}{0.6} = 4.2\ k\Omega.$

Having REXT > 4.2 kΩ will avoid the VREF output to collapse but it will nevertheless induce a voltage drop that needs to be taken into account.

$$VREF = \frac{Rext}{Rref + Rext}.Vref\_int$$

Table 3: Effect of external resistor on VREF level (calculated for Rref = 200 Ω)

Rext [kΩ]	VREF [V]	Voltage Drop [mV]
6.18	2.42	78
10	2.45	49
51.1	2.49	9.75

5. External VREF

It is possible to use an external reference voltage in the range specified on Table 1 and Table 2. Due to the reference current limitation already mentioned in previous sections, it is necessary to use a buffered signal (cf. Recommended configuration: Buffer amplifier connected to VREF).

In case of multisensory application (cf. Recommended configuration for multisensory application: Same reference level) it is possible to reduce the current limitation by disabling the internal resistor. Contact Melexis to have more information on this solution.

5.1. Recommended configuration: Buffer amplifier connected to VREF

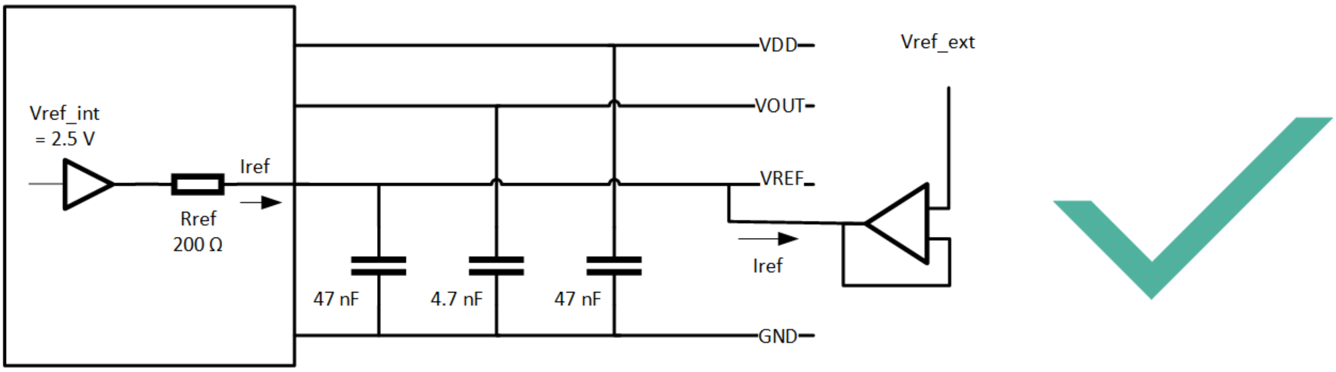

Figure 4: Good configuration for Vref used as an input

VREF_EXT is provided by the application circuit:
Vref_ext = 1.25V (example)

VREF is held to Vref_ext thanks to the buffer amp:
VREF = Vref_ext = 1.25V

5.2. Recommended configuration for multisensory application: Same reference level

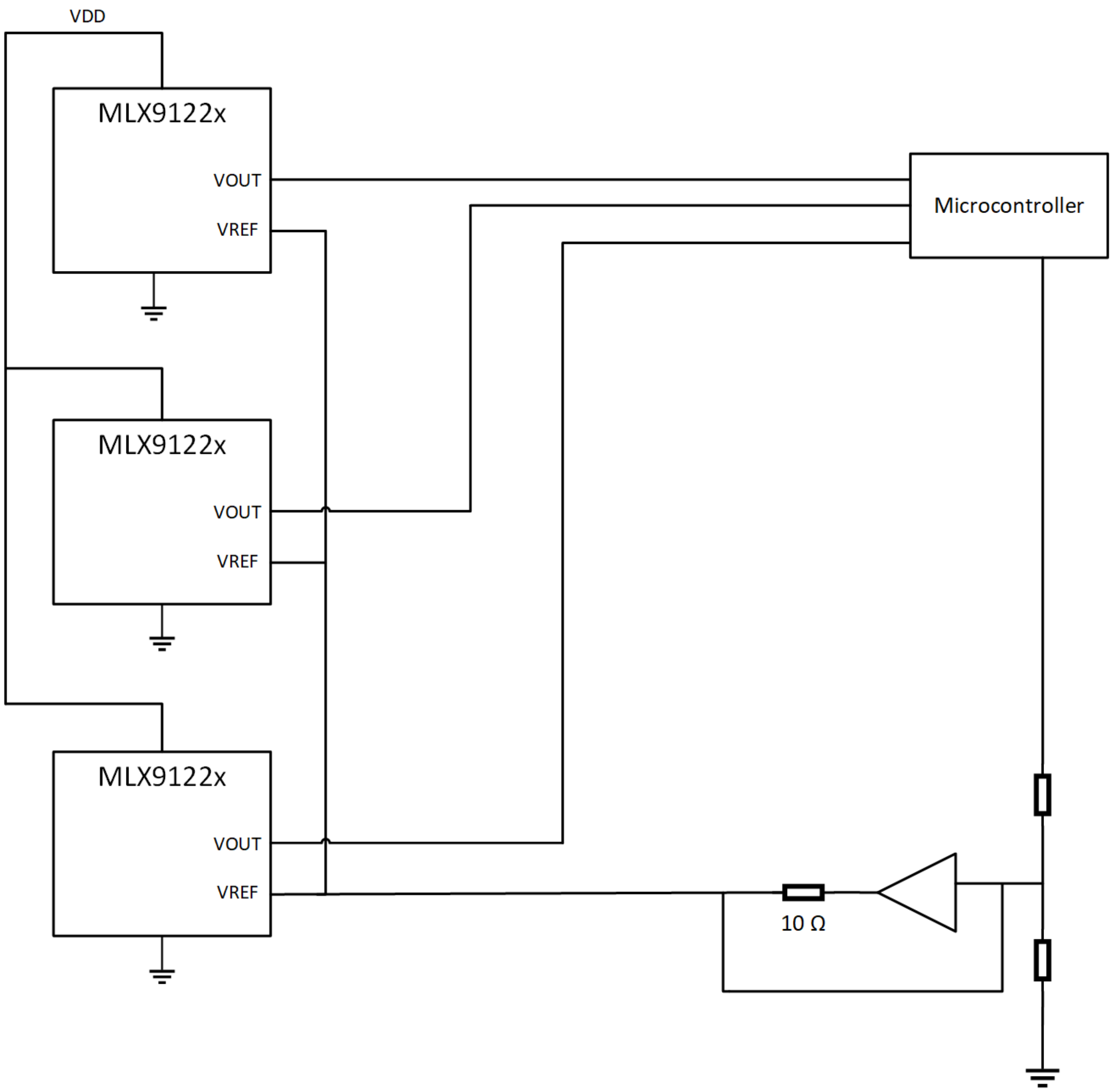

Figure 5: Configuration with multiplexed sensor referenced with the same level

6. Polarity of the output

6.1. Bipolar version

The VREF value corresponds to the value of the output at 0 A. By configuring it as half of the supply, the output is set to be bipolar hence, the current can be measured positively and negatively. **Error! Reference source not found.** shows the output of a bipolar MLX91220 programmed with a sensitivity of 80 mV/A. As the MLX91220 supply voltage is 5 V, the reference voltage is set to 2.5 V.

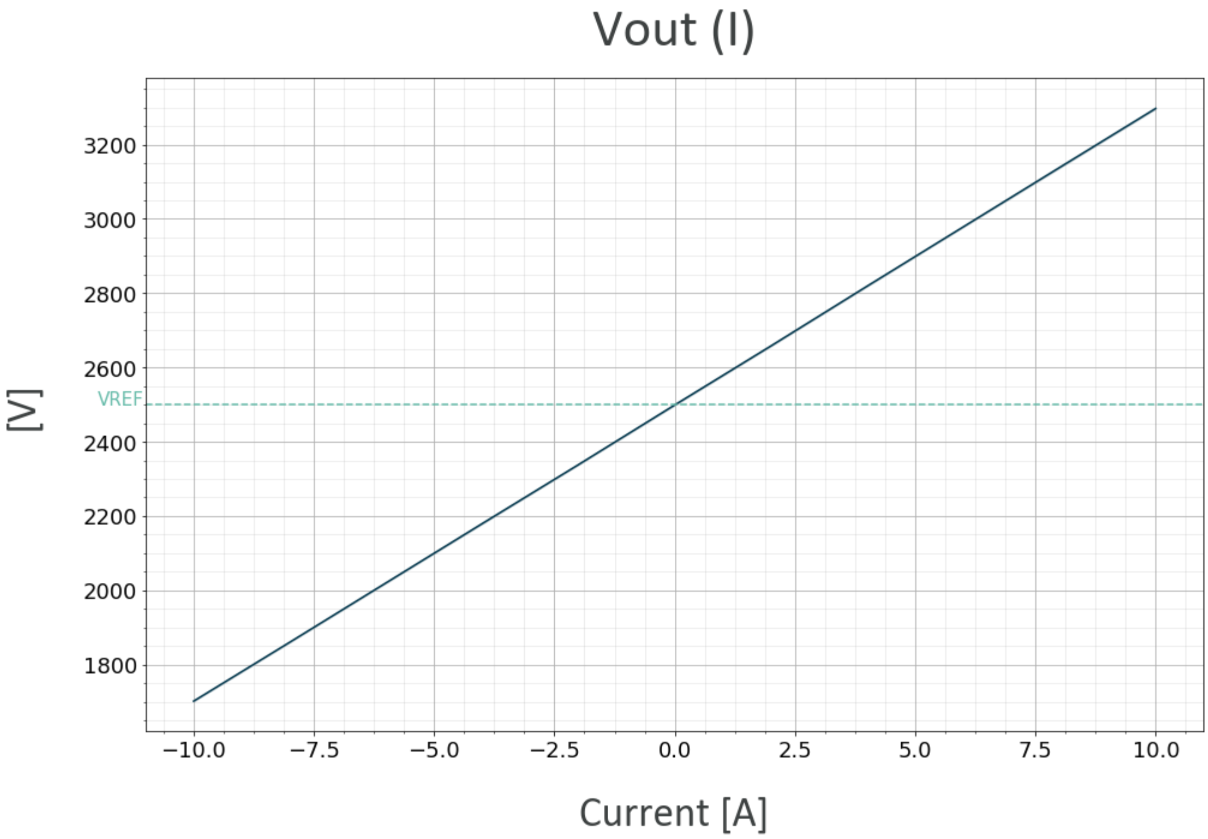

Figure 6: Output range of a bipolar MLX91220 for I=[-10 A ; 10 A]

6.2. Unipolar version

If only one polarity of the current needs to be sensed, the reference pin can be set to 0.5 V to have a doubled linear output range.

The reference pin voltage can be set externally as described in the previous sections or one can order a unipolar version directly where the reference voltage is set to 0.5 V internally. The polarity of the sensor is defined in the highlighted part of the product code: MLX9122xKDx-A**U/B**x-0xx. **U** stands for unipolar and **B** for bipolar.

Figure 7 shows the output of a unipolar MLX91220 programmed with a sensitivity of 80 mV/A. Reference pin is set to 5 V.

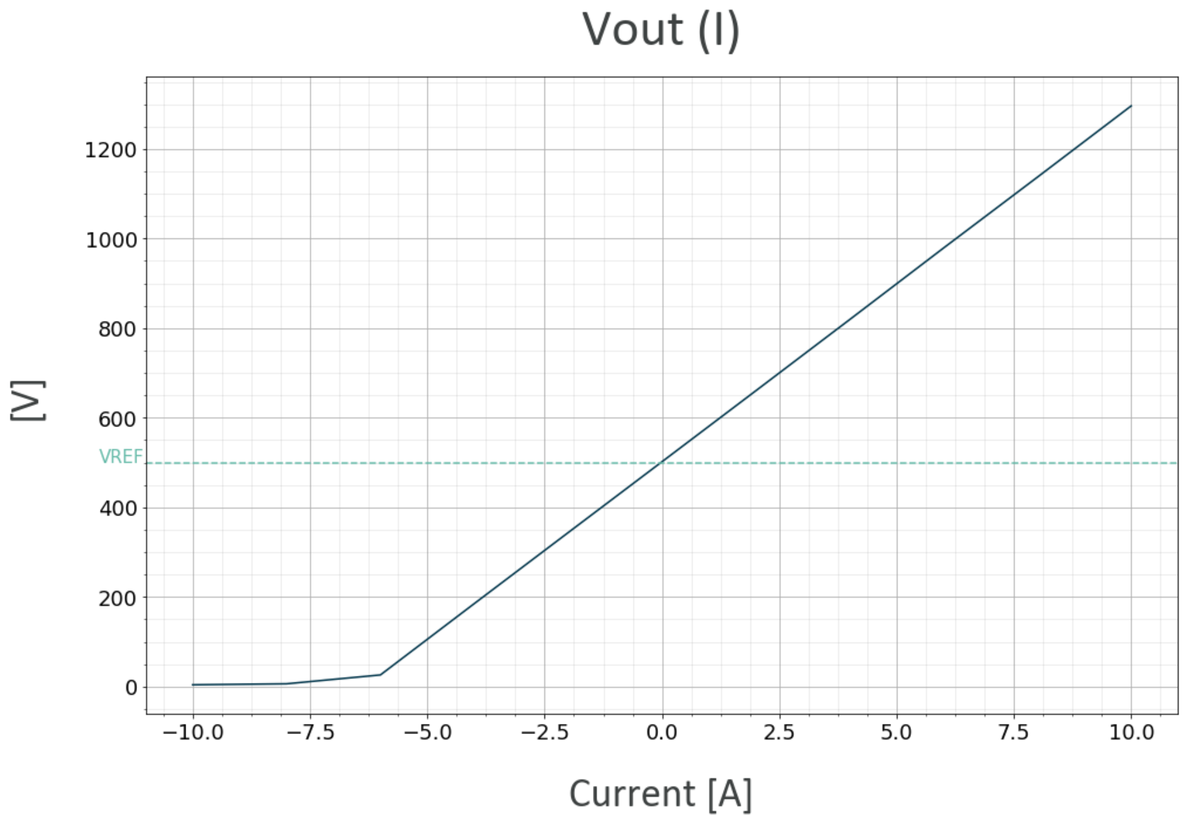

Figure 7: Output range of a unipolar MLX91220 for I=[-10 A ; 10 A]

7. Disclaimer

IATF 16949 and ISO 14001 Certified

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8. Revision history table

Revision	Date	Description/comments
1.0	December 2020	Initial release