Application Note

RainLight - Photo diode non linearity compensation

Contents

1. Scope

This document describes how the photo diode nonlinear behavior is compensated by the Melexis RainLight sensors. It also gives instructions which will lead the user to find the optimized parameter settings for PD_COMP registers.

2. Nonlinear behavior of photo diode

The photo diode current is not linear proportional with the input light power density. To translate this effect into a rain light sensor system, it means that **for different ambient light conditions, the same light pulse level will give a different photo current pulse** in the photo diode.

This effect exists in all types of photo diodes from all suppliers, but the amplitude of nonlinearity can be different. If one normalizes the pulse amplitude at absolute dark condition, or 0 DC photo current, the relative amplitude of light current signal caused by same light pulse for all different ambient light current conditions can be drawn like the chart below.

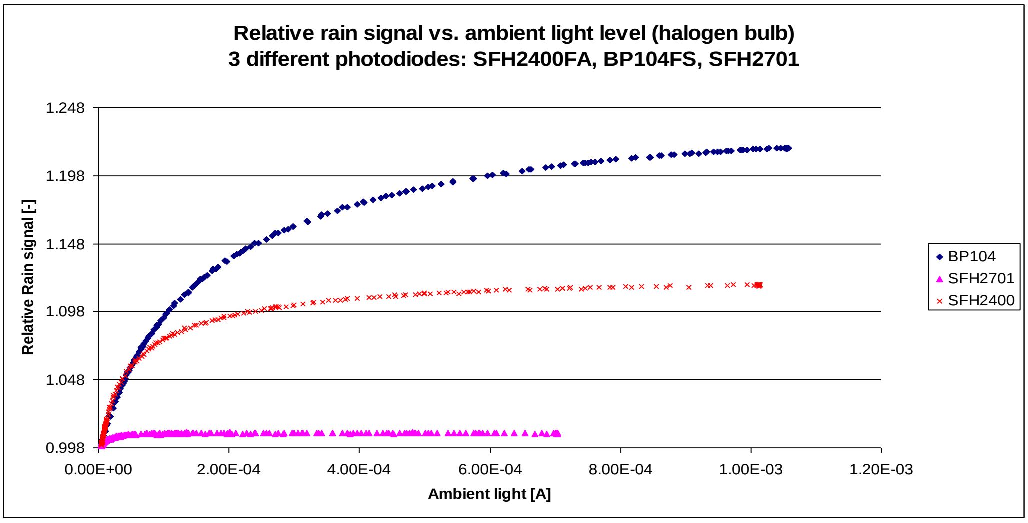

Figure 1: Nonlinear behavior of different photo diode

The curves have a logarithmic shape. The shape of the nonlinear curve is not only photo diode type depended, but also light source spectrum depended. Even for the same photo diode in a different optics system or in a different windshield, the effect of this nonlinearity could be different.

Once photo diode, optical system and glass are fixed, the nonlinear property should be unique.

3. MLX RLS PD compensation

As the DC part of photo current is flowing into the MLX RLS and is measured by the chip itself, the current is used further as input for the PD compensation circuit. Based on this input current, the PD compensation circuit will generate 5 different reference currents like the 5 blue curves in the picture blow.

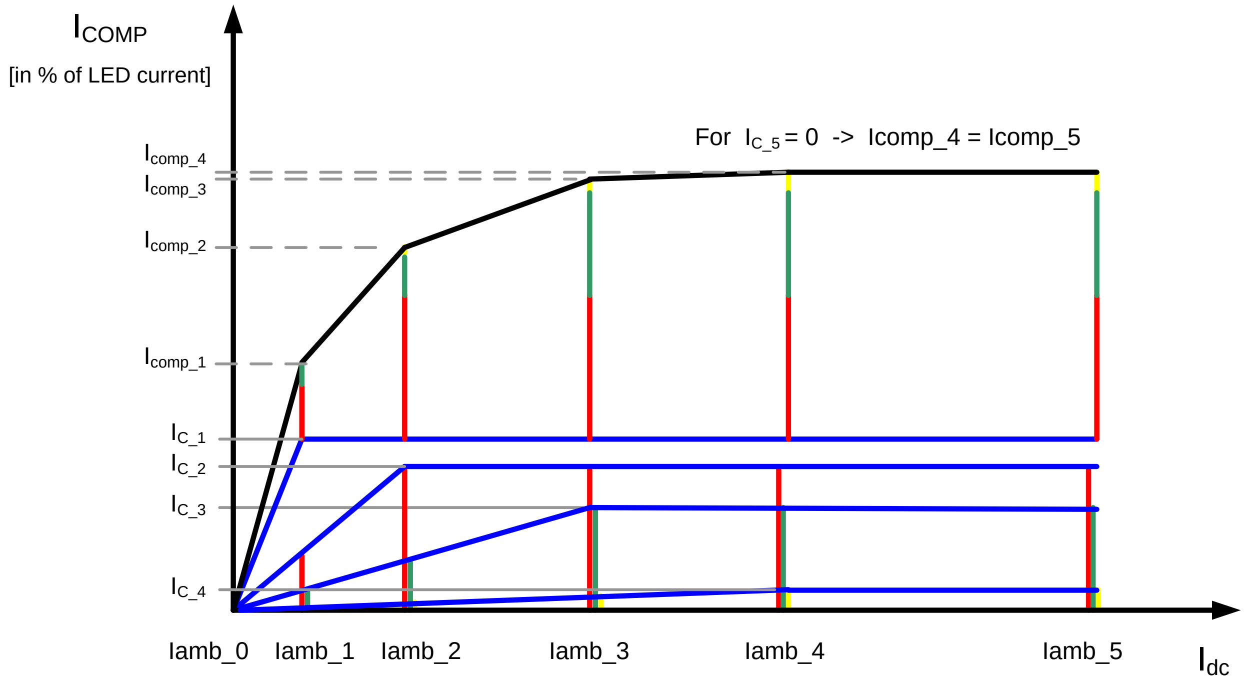

Figure 2: Example of a compensation curve I_{COMP} for I_{C_5}=0. The dc-currents of the corner points are fixed in the design and cannot be influenced. The compensation components I_{C_1}...I_{C_5} are defined by the registers DC_COMP_IC1...5 with 4bits each. The resulting compensation characteristics are shown in the black graph.

For each current, the amplitude of the max current, or Ic_x level displayed in the picture above, can be controlled by the setting of PC_COMP_ICx<3:0> register. In the end those 5 reference currents are summing together to form Piece Wise Linear curve as shown as the black curve in the picture above.

The resulting curve is inversed and multiplexed together with the DAC output. In this way the exponential like nonlinear PD current will be internally compensated within tolerated error rate.

The chart below shows an example of the compensation.

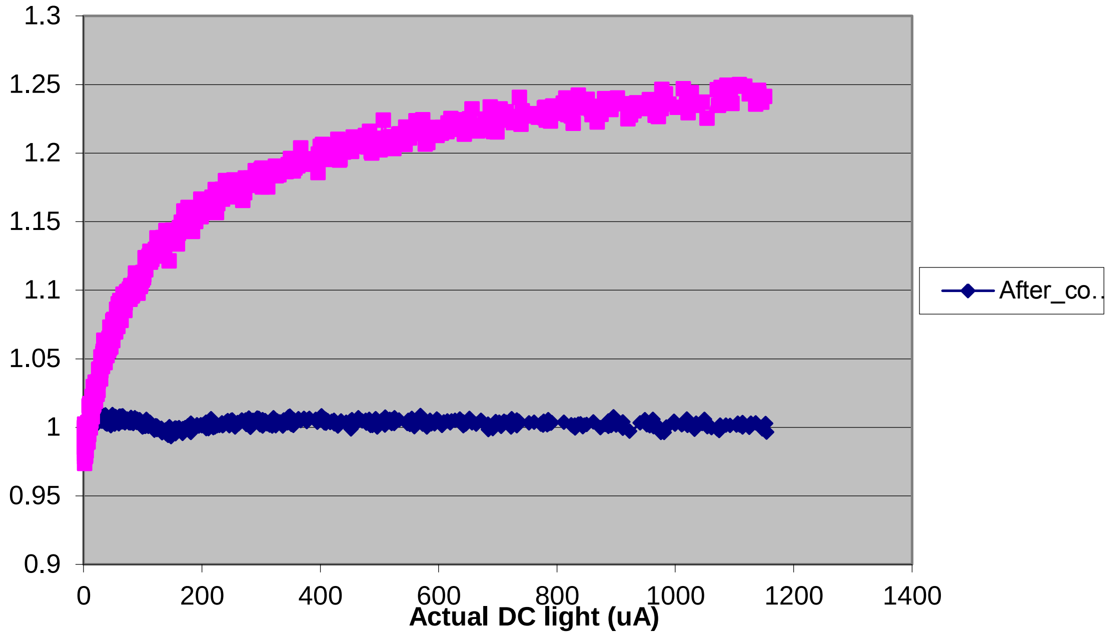

Figure 3: comparison between before and after PD compensation

4. Instructions to find the correct parameters

In the MLX RLS datasheet is a description on how to calculate those parameters. Normally after calculation, a reasonable result will be found. However those values will never be perfect as the calculations are based on theoretical parameters. As a consequence, some fine tuning has to be performed to get the optimized settings.

The steps to fine tune the setting are as follows.

Step 1:
For a certain type of optical module and glass, one should first sweep the ambient light from dark to the most bright condition without DC compensation applied (EN_DCCOMP = 0), until the DC light measured by the MLX RLS reaches 900uA. A halogen lamp is suggested as a light source as it is the most similar to sunlight.

Step 2:
Calculate the input current for a rain signal based on GAIN_ADJ settings and DC input current. Normalize the rain signal to 1 when the DC light input is 0 and draw the curve as in Fig1.

Step 3:
Find the 5 input points which are needed in the formula described in the datasheet.

Step 4:
Calculate PD_COMP_ICx<3:0> values using the datasheet description and write it into the registers. Enable DC_COMP and perform the sweep again. Check if result is fine.

Step 5:
If the result curve shows over compensation, one should decrease the PD_COMP_IC<3:0> values.

If the result curve shows under compensation, one should increase the PD_COMP_ICx<3:0> values.

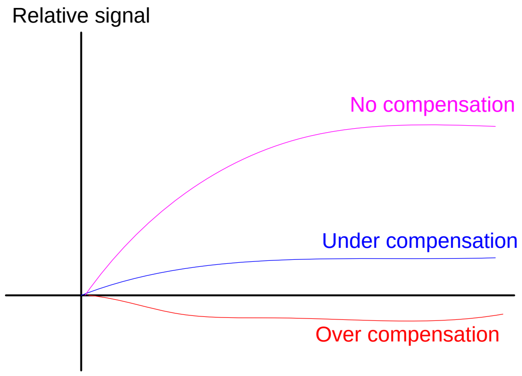

Figure 4: over and under compensation

Please always change the register value of PD_COMP_IC5<3:0> first. Then modify 4, 3, 2, 1 and 0. After every modification, rewrite the values into the registers to evaluate the result.

The reason to start with changing PD_COMP_IC5 can be explained by looking at Figure 2. The slope of the last piece of the curve is controlled by only one reference current input (PD_COMP_IC5<3:0>) while are the other pieces are the sum of multiple reference currents.
After piece 5 is defined, one can continue to piece 4 and so on.

Note: when playing with PD_COMP_IC5<3:0>, the target is to get the maximum “flatness” of the compensated part, not the smallest error. If all the pieces are tuned like this, the best result will be achieved.

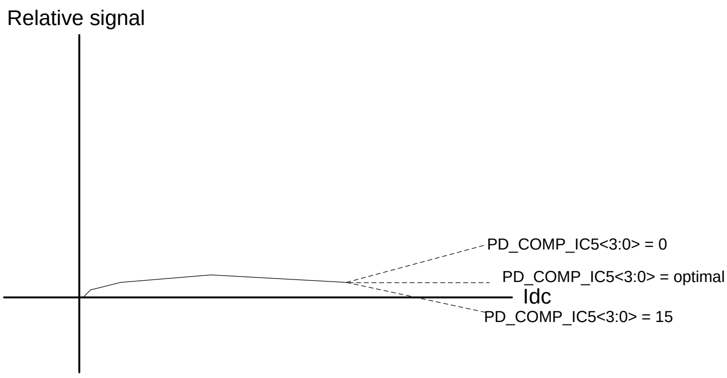

Figure 5: optimize each setting

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