High speed measurement with UV photodiodes

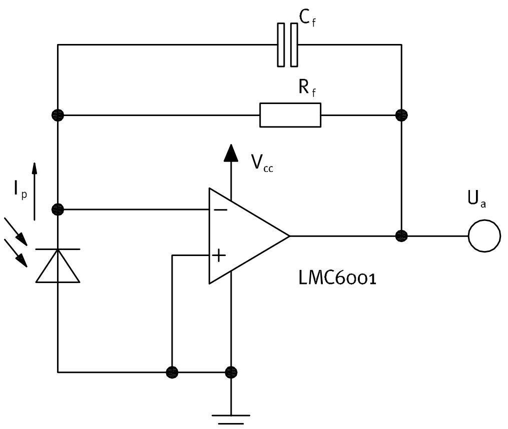
approaches and limits

INTRODUCTION

Usually, the measurement of ultraviolet light is a "steady source" measurement which means that the signal to be measured does not rapidly change in irradiance over time. However, sometimes fast changes of the light intensity need to be measured. This report explains the approaches and limits.

SIGNAL CONDITIONING WITH TRANSIMPEDANCE AMPLIFIERS (TIA)

Using TIAs for signal conditioning is a common and convenient method when using UV photodiodes. Their major limitation is the fact, that their bandwidth decreases in the same magnitude, as the input current decreases.
The following picture shows a basic circuit example of a transimpedance amplifier.



Calculations and Limits:

$U_a = I_p \times R_f = 0 \ldots \sim V_{cc}$

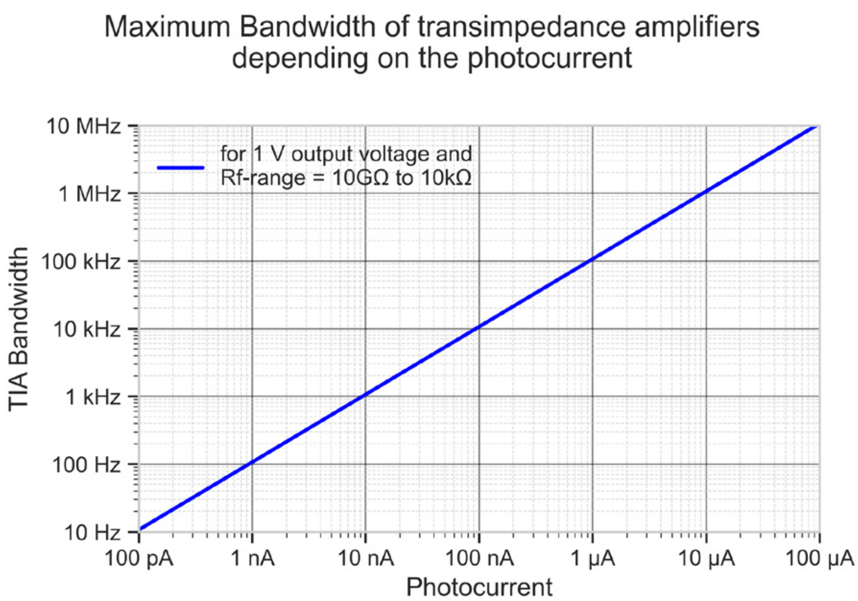
$U_{a,max}$ depends on load and amplifier type

$R_f = 10k\Omega \ldots \sim 10G\Omega$, $C_f \geq 3pF$
Recommendation: $R_f \times C_f \geq 10^{-3}s$
$I_{p,max} = U_{a,max} \div R_f$

Bandwidth = DC ... $\frac{1}{2\pi \times R_f \times C_f}$

Example:
$I_p = 20nA$, $R_f = 100M\Omega$, $C_f = 100\ pF$
$U_a = 20 \times 10^{-9}A \times 100 \times 10^{6}\Omega = 2V$

Because the photocurrent of a UV photodiode usually does not exceed ~10 µA, the achievable bandwidth will remain lower than 1 MHz for a desired output signal of 1 Volt. The following diagram depicts the dependence of the bandwidth in relation to the available photocurrent. Actual bandwidth values are limited by the used TIA circuit and are often lower than the values shown in the diagram.

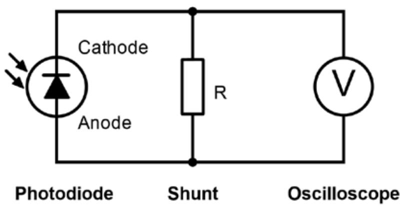


High speed measurement with UV photodiodes

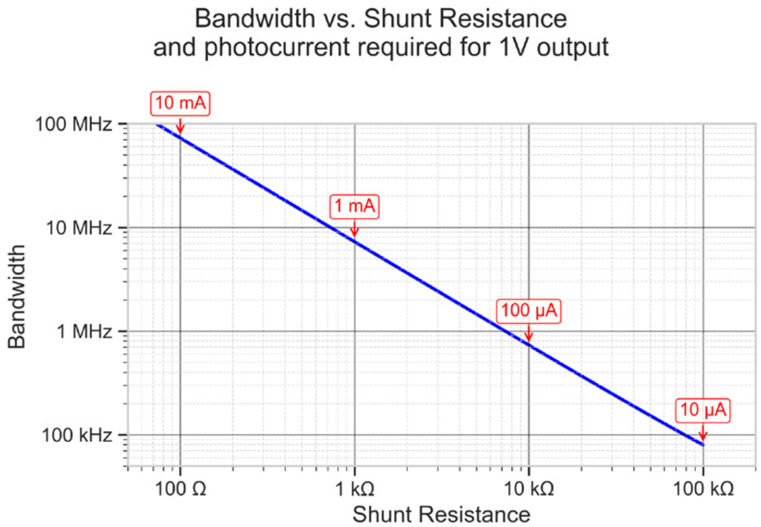
approaches and limits

SIGNAL CONDITIONING WITH A SHUNT RESISTOR

A very simple possibility is to measure the photocurrent as voltage drop over a shunt resistor.



This approach can offer large bandwidths, but requires relatively large photocurrents. The below picture shows the basic circuit with the photodiode and the shunt resistor connected to an oscilloscope. This method allows, theoretically, a bandwidth up to 100MHz. The below table shows the relation between the desired bandwidth and the shunt resistor value to be applied. The red annotations show which photocurrent (generated by the photodiode) is needed to obtain a voltage of 1 V at a certain bandwidth and certain shunt resistor value.



As the current of a UV photodiode usually does not exceed 10µA, the voltage will decrease accordingly.

Example: The photocurrent is 10 µA and the desired bandwidth is 7 MHz. In this case a 1kOhm resistor is to be applied. The voltage decreases by factor 1mA/10µA = 100. Accordingly the voltage will be 10 mV.

Please note that the values for the bandwidth at a certain shunt resistor value are always lower than depicted in the graph. The below picture shows an equivalent circuit diagram of this setup to illustrate, how many parameters have an influence on the performance of such measurements.