

# Detecting Light in the presence of Light

## *Unwanted “Ambient” Light ?*

Sun or Sky - Street or Office lighting - Fluorescence source - Adjacent optical equipment - Carrier light in modulated systems ... Mainly low frequency or “d.c. light”

## *Benefits of removing “Ambient” Light in detectors*

Signal processing or post amplification easier - Measurements more accurate - Signal to Noise increased - New techniques enabled ...

## *Applications*

Communications (esp. FSO) - Research - Measurement (esp. non-contact or density) - Surveying - Measuring laser noise ...

# Removing the effect of “Ambient” Light

## *Before the detector*

Optical techniques :- Filters - Plates - Mirrors - Hoods ...

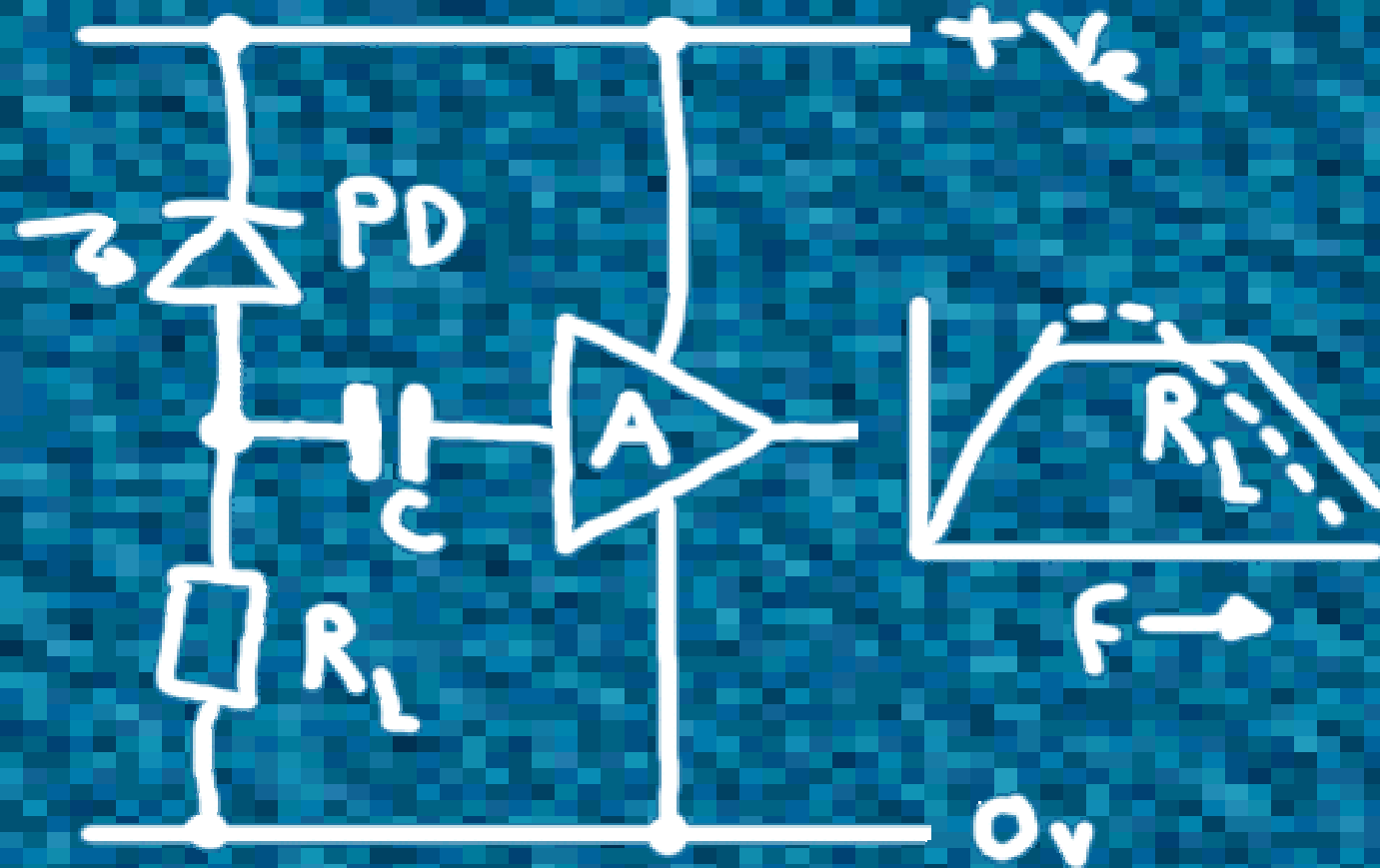
## *After the detector*

Signal Processing :- DSP techniques - Lock-in amplifiers -  
Filters (analogue/software) - a.c. coupling ...

## *Within the detector*

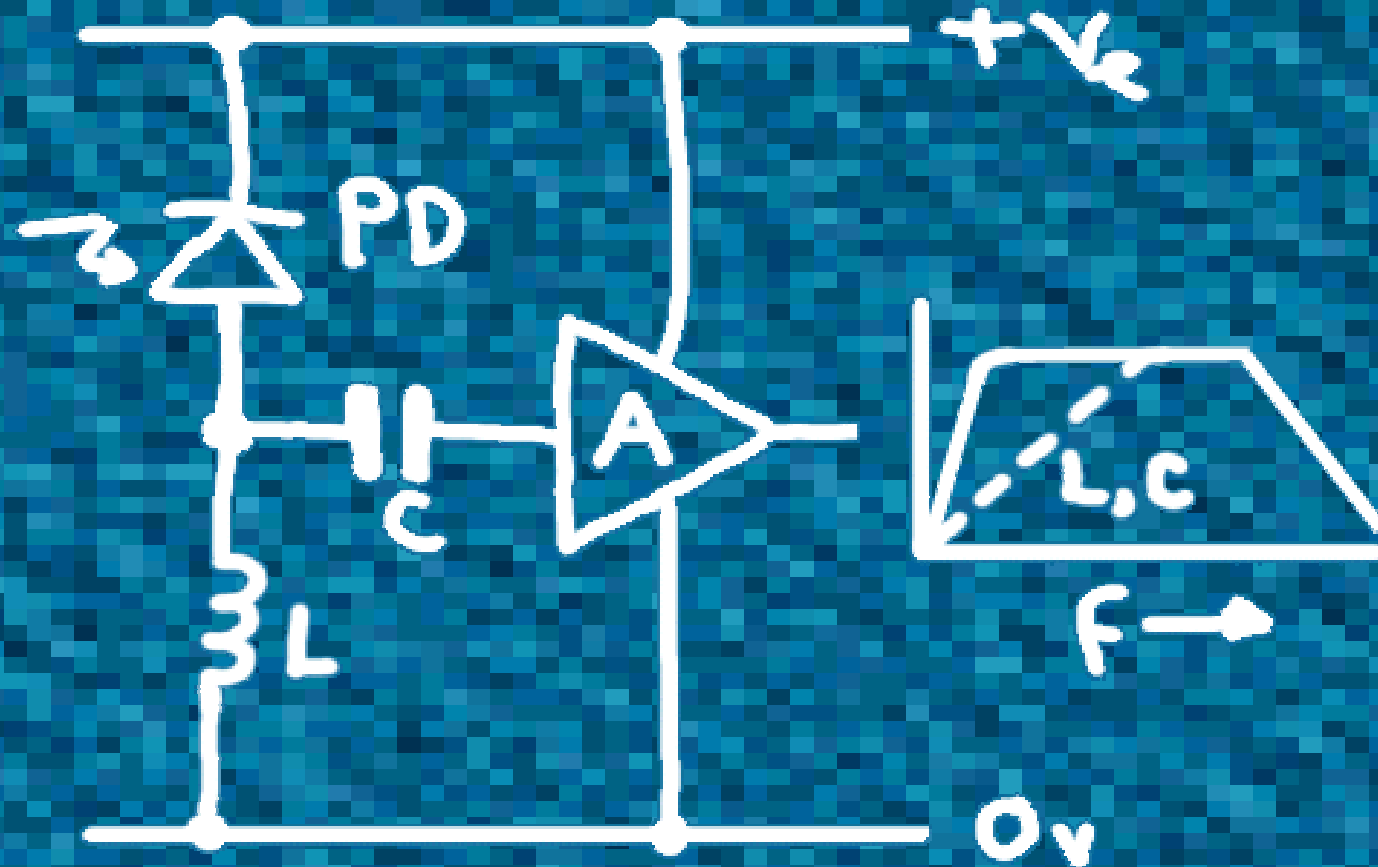
Frequency selection :- a.c. only loading or coupling - d.c.  
subtraction - High gain low noise amplifier RF impedance  
matched to the detector ...

# 1) Removing the effect of “Ambient” light from the simple photo-diode detector



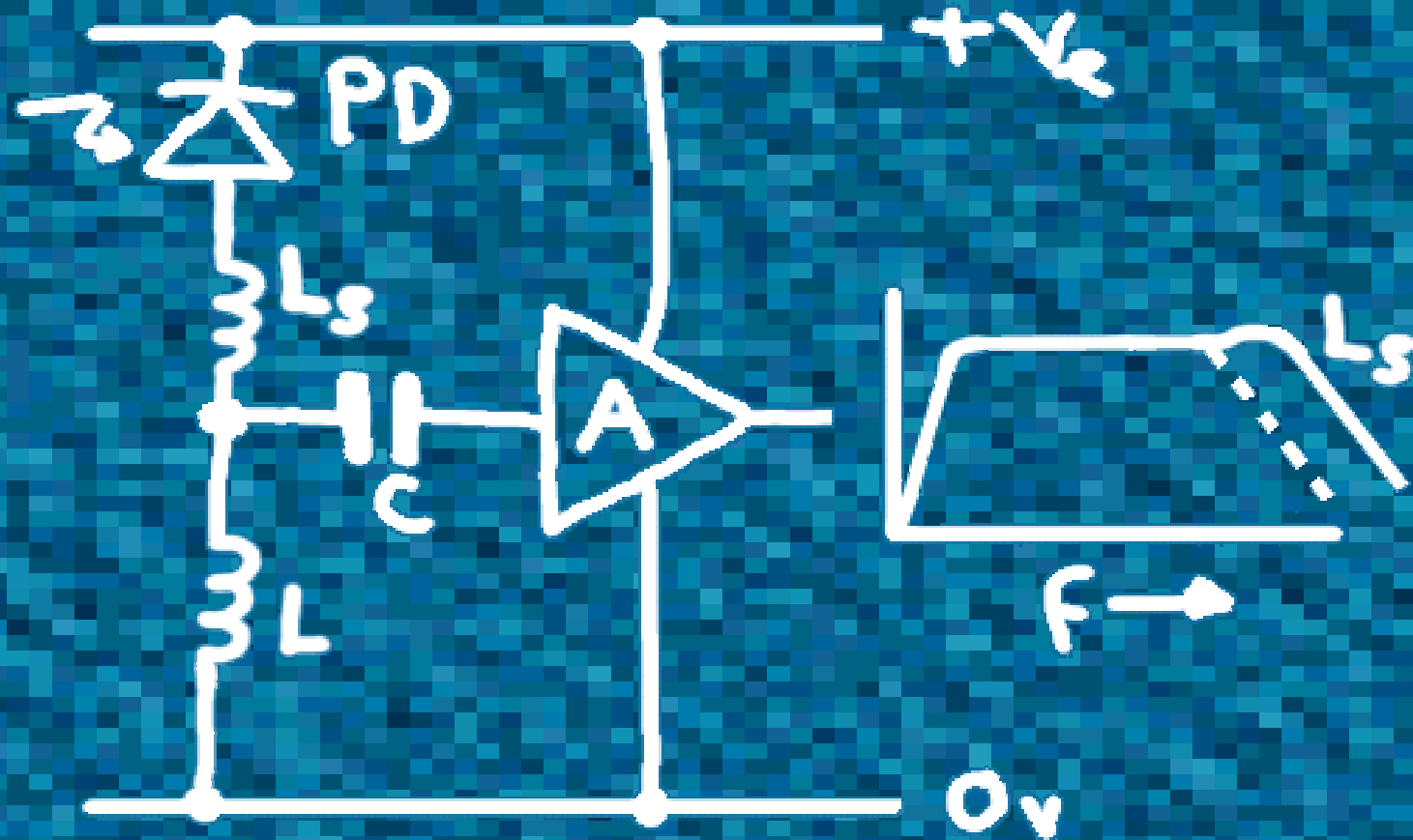
C prevents “d.c. light” affecting the amplifier input bias —  
Bandwidth and sensitivity are determined by  $R_L$ , PD bias (which varies with “d.c. light”), C and the amplifier input impedance

## Inductive load for the photo-diode in the simple detector



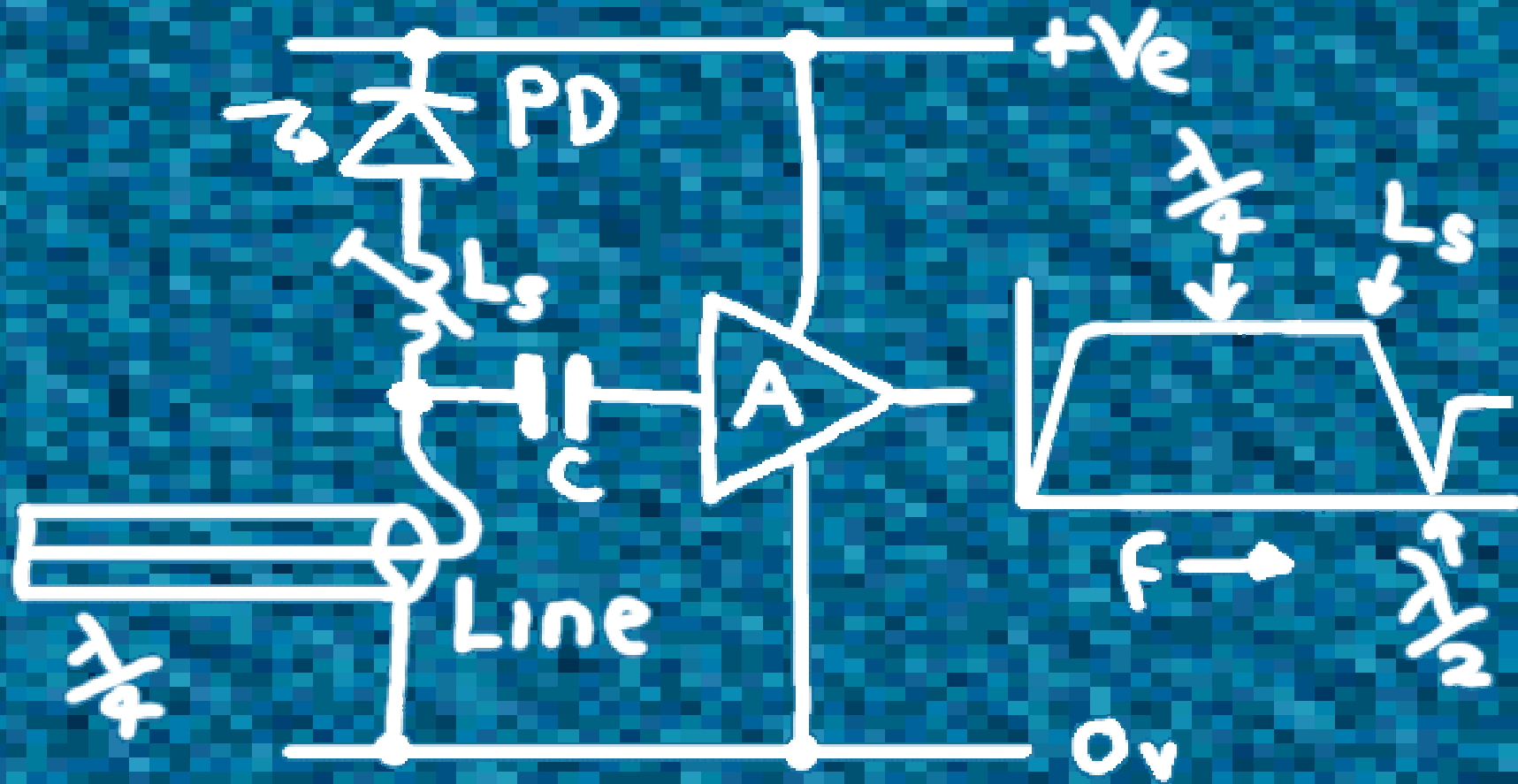
L ensures that “d.c. light” does not change the PD bias —  
Bandwidth is determined by the PD capacitance, L, C and the  
amplifier input impedance

Photo-diode series inductor ( $L_s$ ) can extend the bandwidth of the simple detector



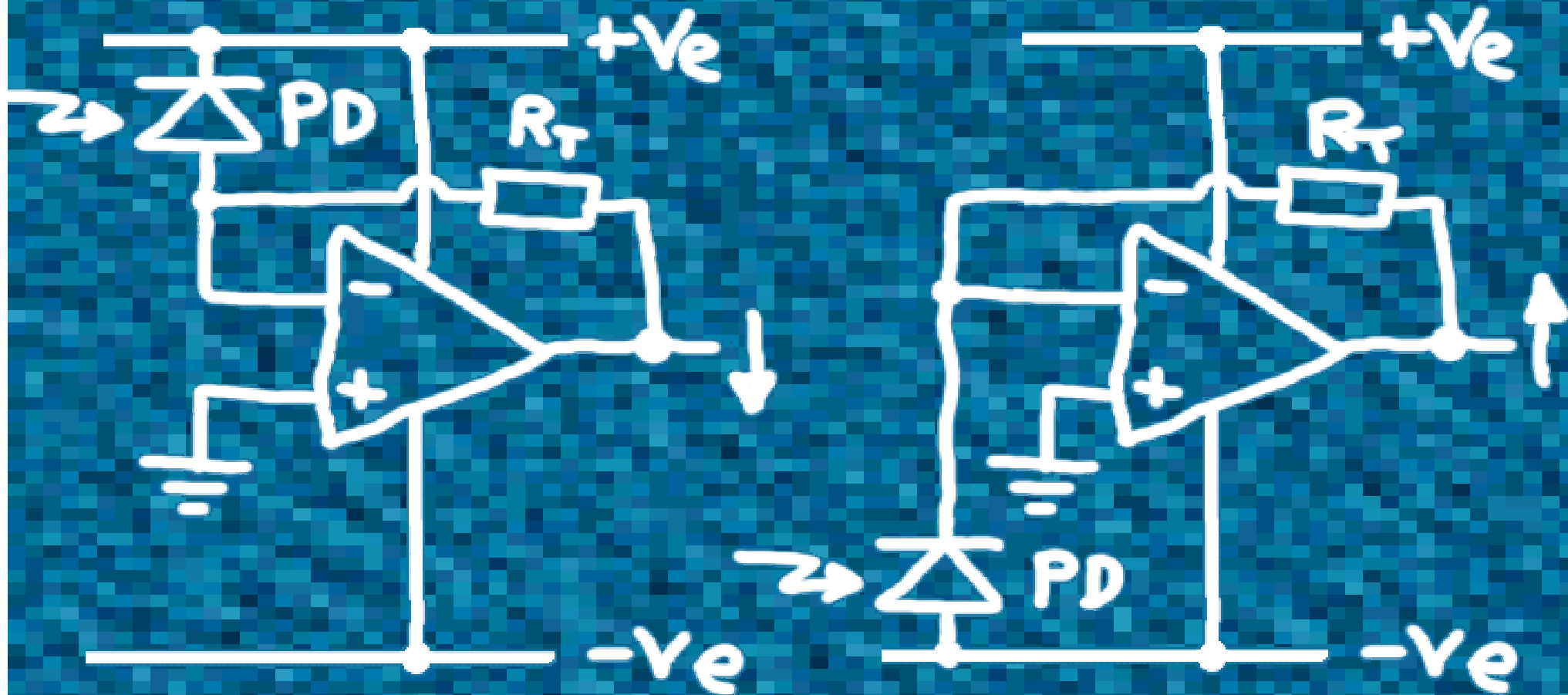
$L_s$  series resonates with the PD capacitance and can extend the bandwidth by “peaking” the upper frequency response — High gains required can make this arrangement very unstable

Replacing the load inductor  $L$  with a transmission line gives a stable extended frequency bandpass response



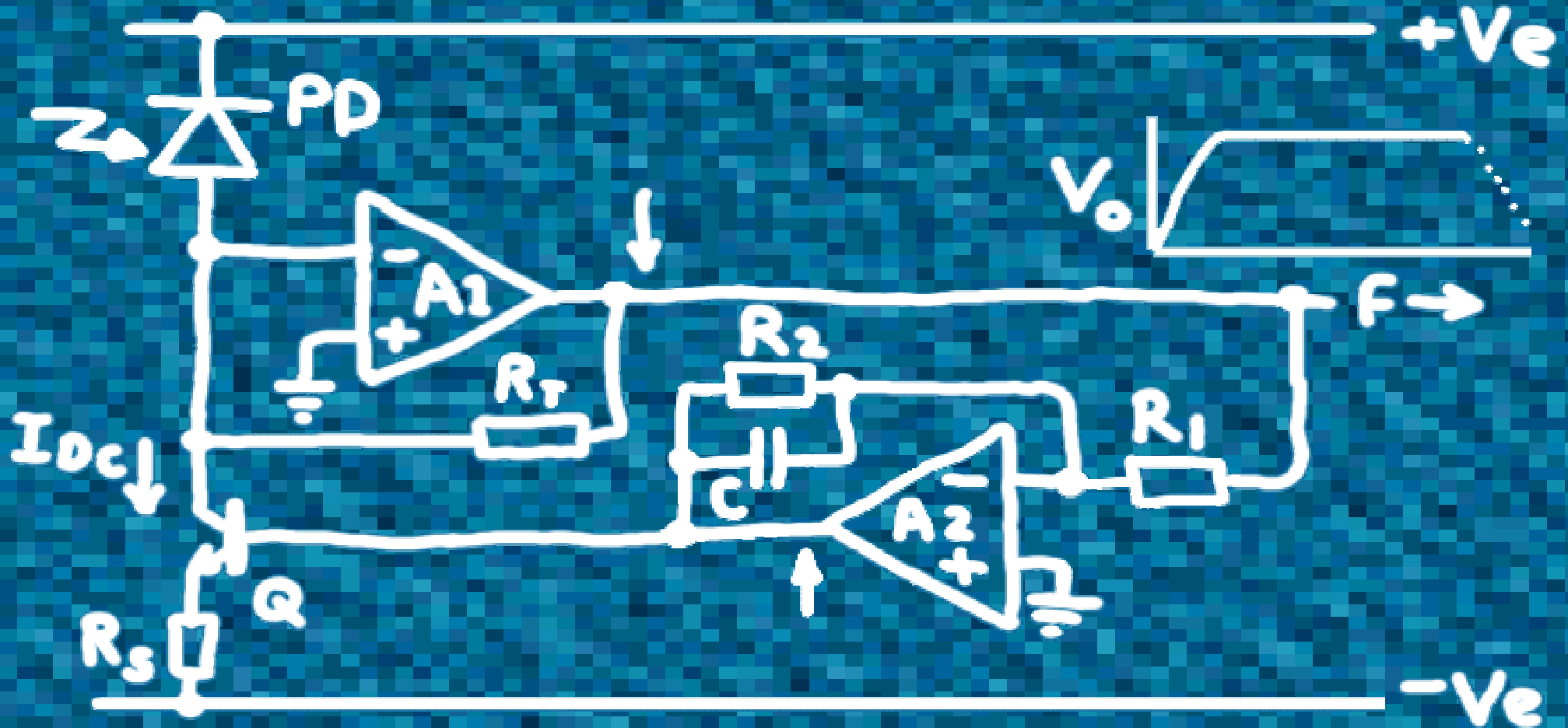
The line is shorted but appears open circuit at  $f = \lambda/4$  where all the PD current goes to the amplifier input —  $C$  can be made large and  $L_s$  is made adjustable to position the corner peak

## 2) Removing the effect of “Ambient” light from a Transimpedance Amplifier (TIA) by subtraction



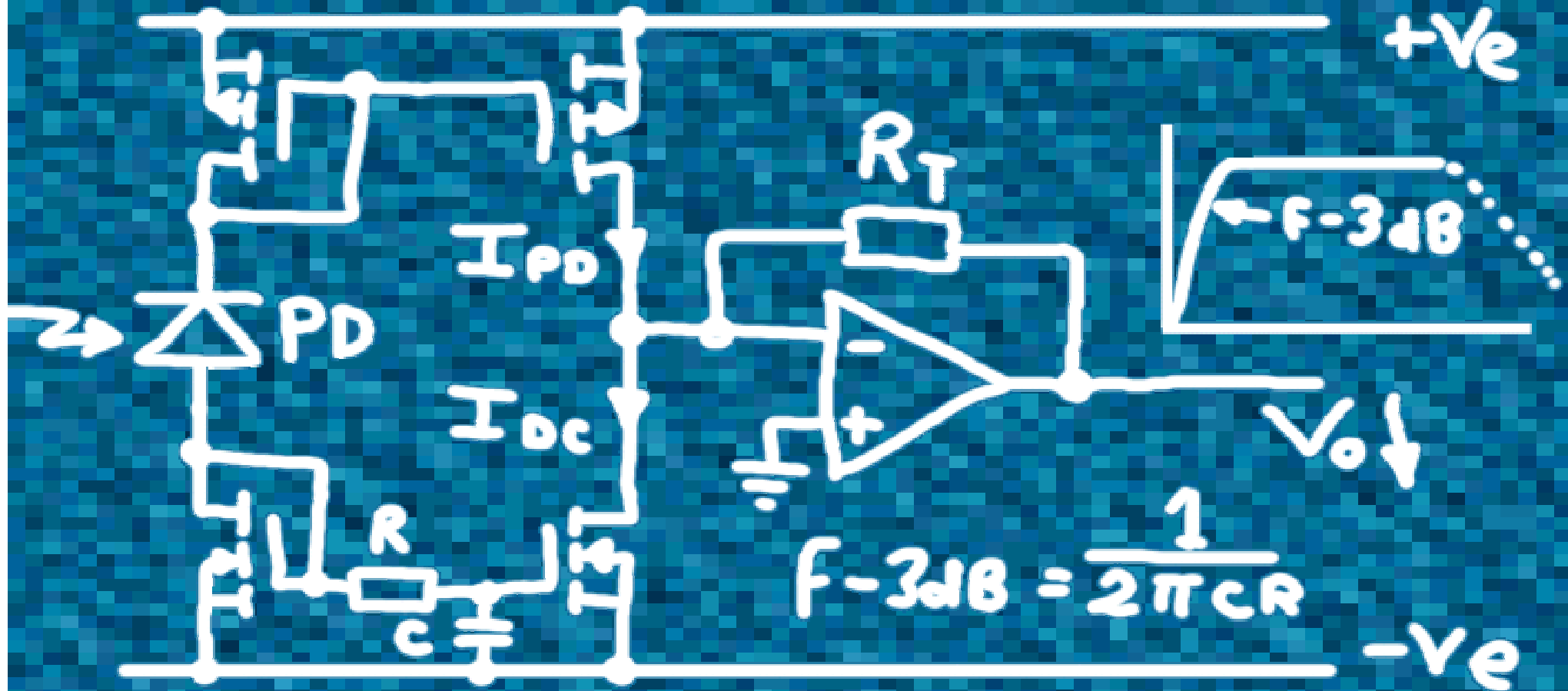
Gain ranges are set by resistor  $R_T$  which converts the PD current to a voltage  $V_o = I_{PD} * R_T$  — The circuit on the left inverts the signal and will be used in the following examples ...

Integrator  $A_2$  amplifies the low frequency components of  $V_o$   
— Current sink  $Q$  then subtracts these (as  $I_{DC}$ ) from  $I_{PD}$



Gain and amount of low frequency subtraction is limited to a range of stable operation — Careful selection of several time constants is often required for each change of  $R_T$  in practice

By using a “bridge” of current mirrors a greater range of  $I_{DC}$  can be subtracted directly from  $I_{PD}$



This arrangement is very stable and the low  $-3\text{dB}$  point is well defined for any gain or PD type — The TIA is now buffered so the PD capacitance can not cause instability as  $R_T$  varies the range

## How do I see the future for free space detectors ?

Further application of traditional radio frequency techniques  
to optimise the light to voltage (or preferably current)  
conversion at higher speeds

Possibly the introduction of RF transmission line or antennae  
techniques “etched” into the detector material to provide very  
large area aperiodic detectors at higher frequencies

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