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 ...

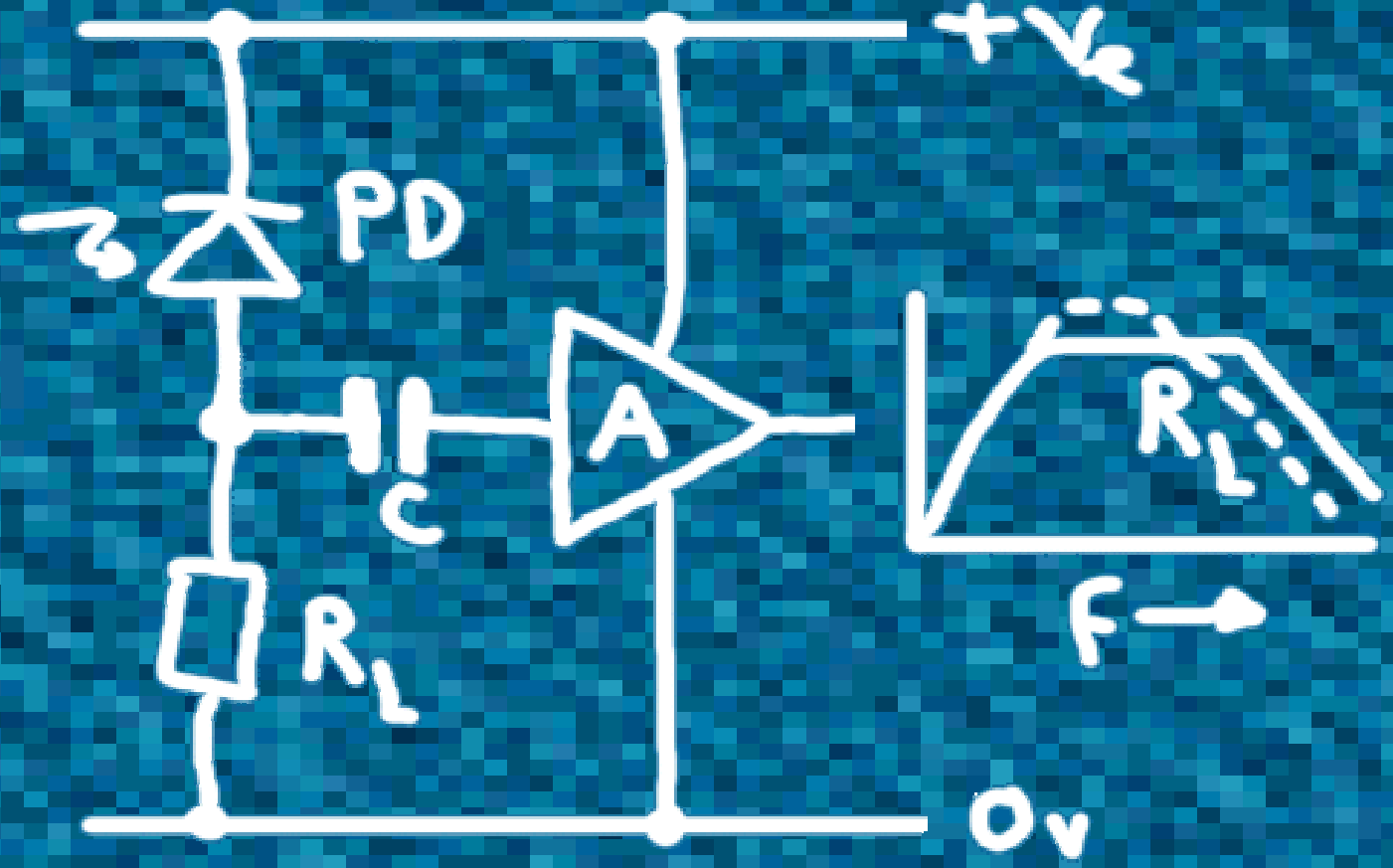
After the detector

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

Within the detector

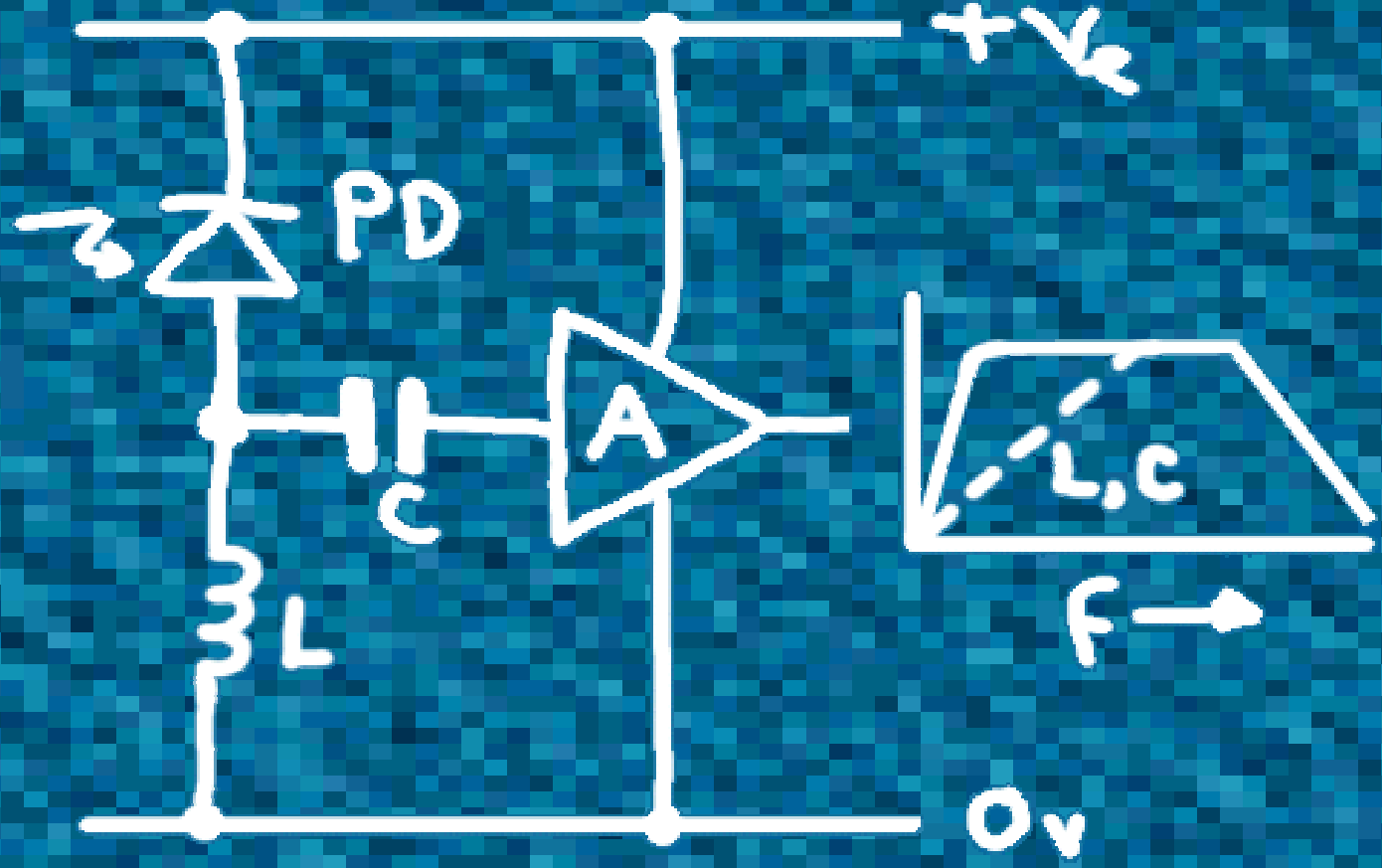
Frequency selection :- a.c. only loading or coupling - d.c. subtraction - High gain low noise amplifier RF impedance matched to the detector ...

1) Removing the effect of "Ambient" light from the simple photo-diode detector



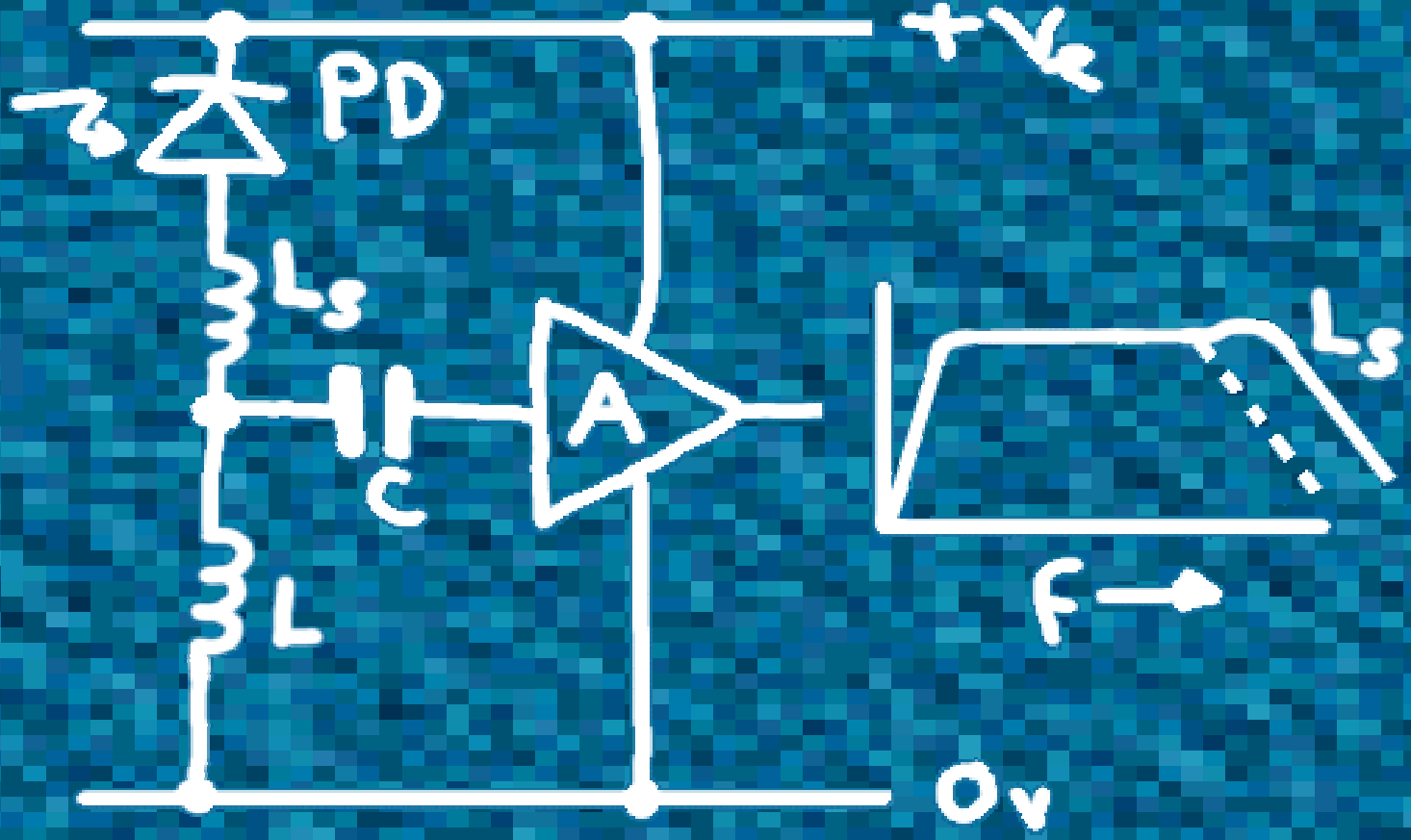
C prevents "d.c. light" affecting the amplifier input bias — Bandwidth and sensitivity are determined by RL, PD bias (which varies with "d.c. light"), C and the amplifier input impedance

Inductive load for the photo-diode in the simple detector



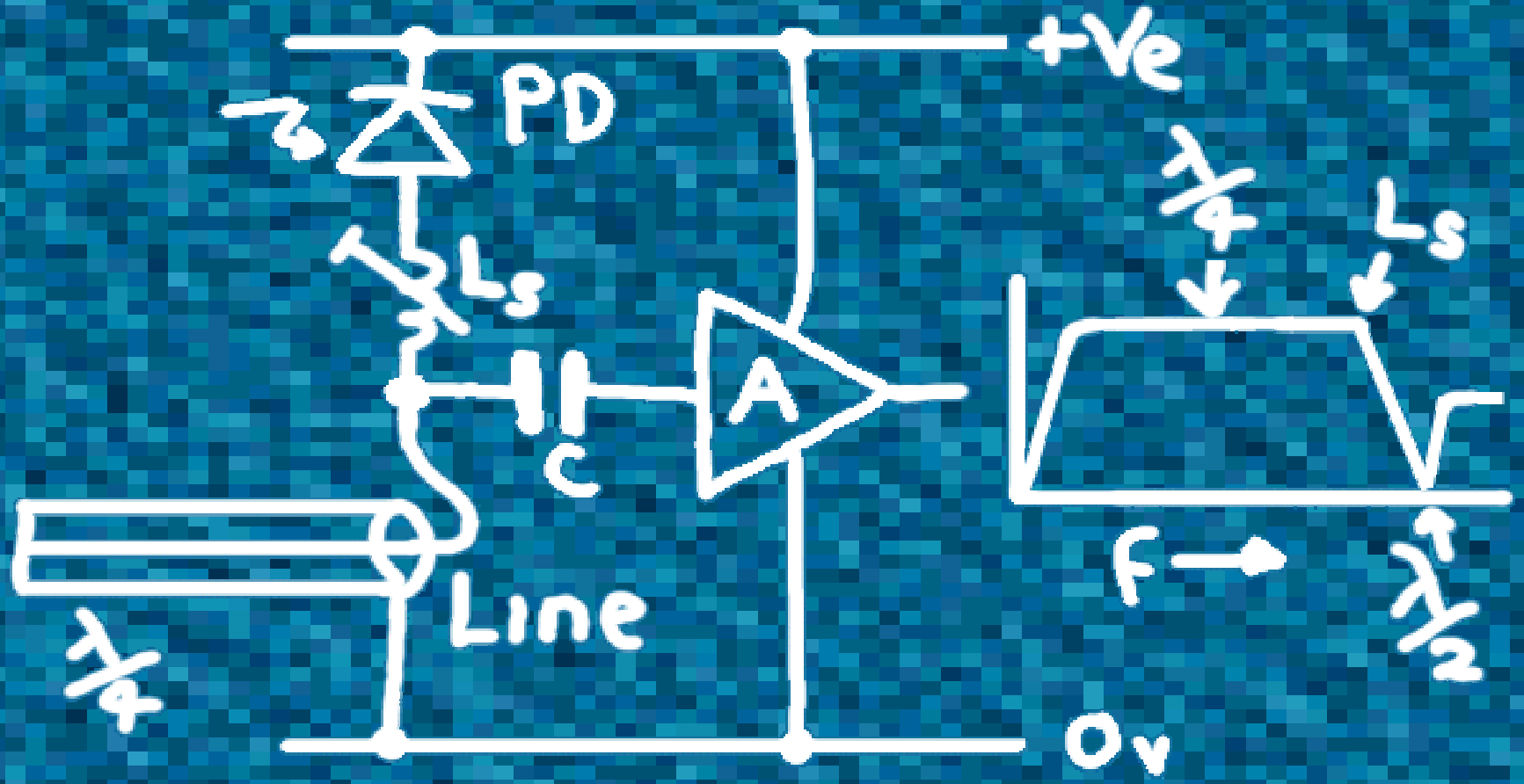
L ensures that “d.c. light” does not change the PD bias — Bandwidth is determined by the PD capacitance, L, C and the amplifier input impedance

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



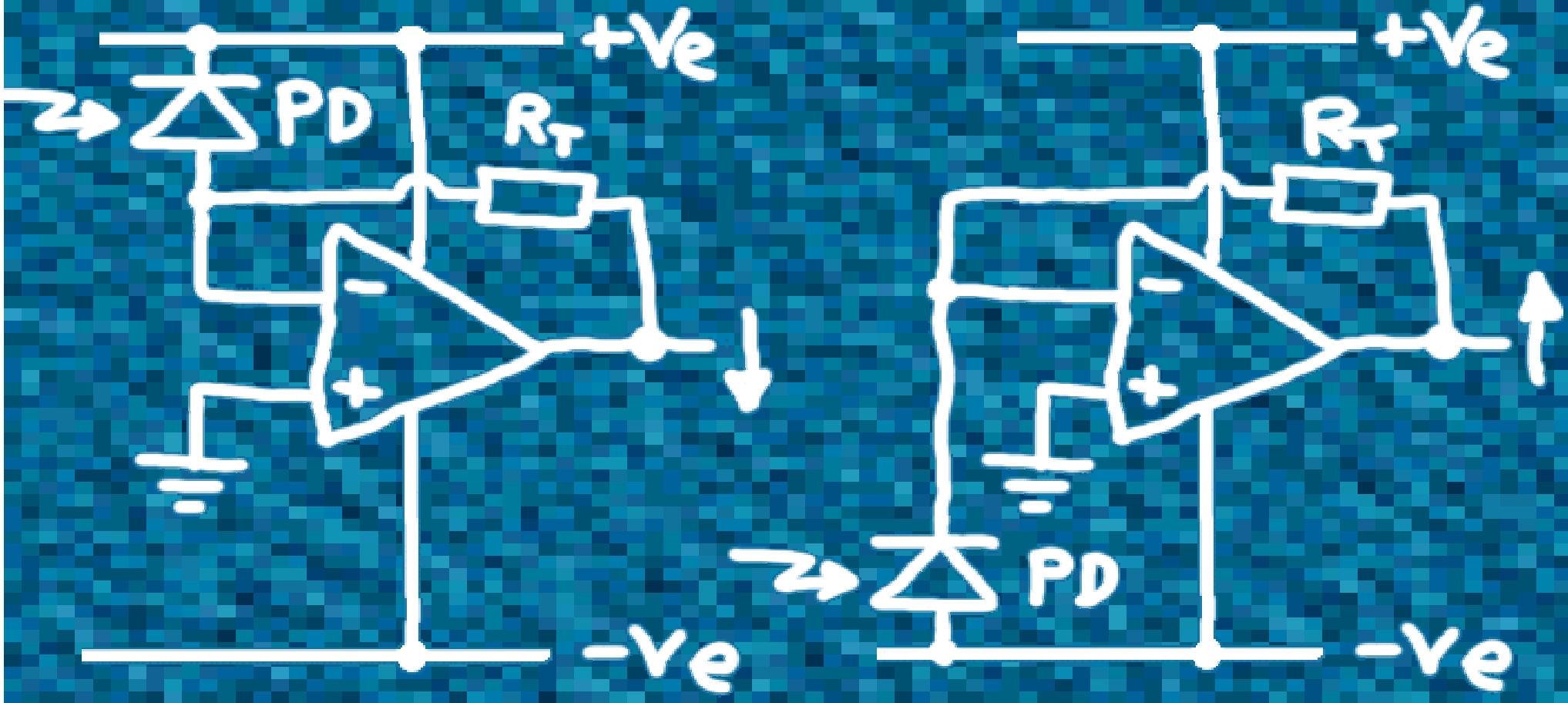
Ls series resonates with the PD capacitance and can extend the bandwidth by “peaking” the upper frequency response — High gains required can make this arrangement very unstable

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



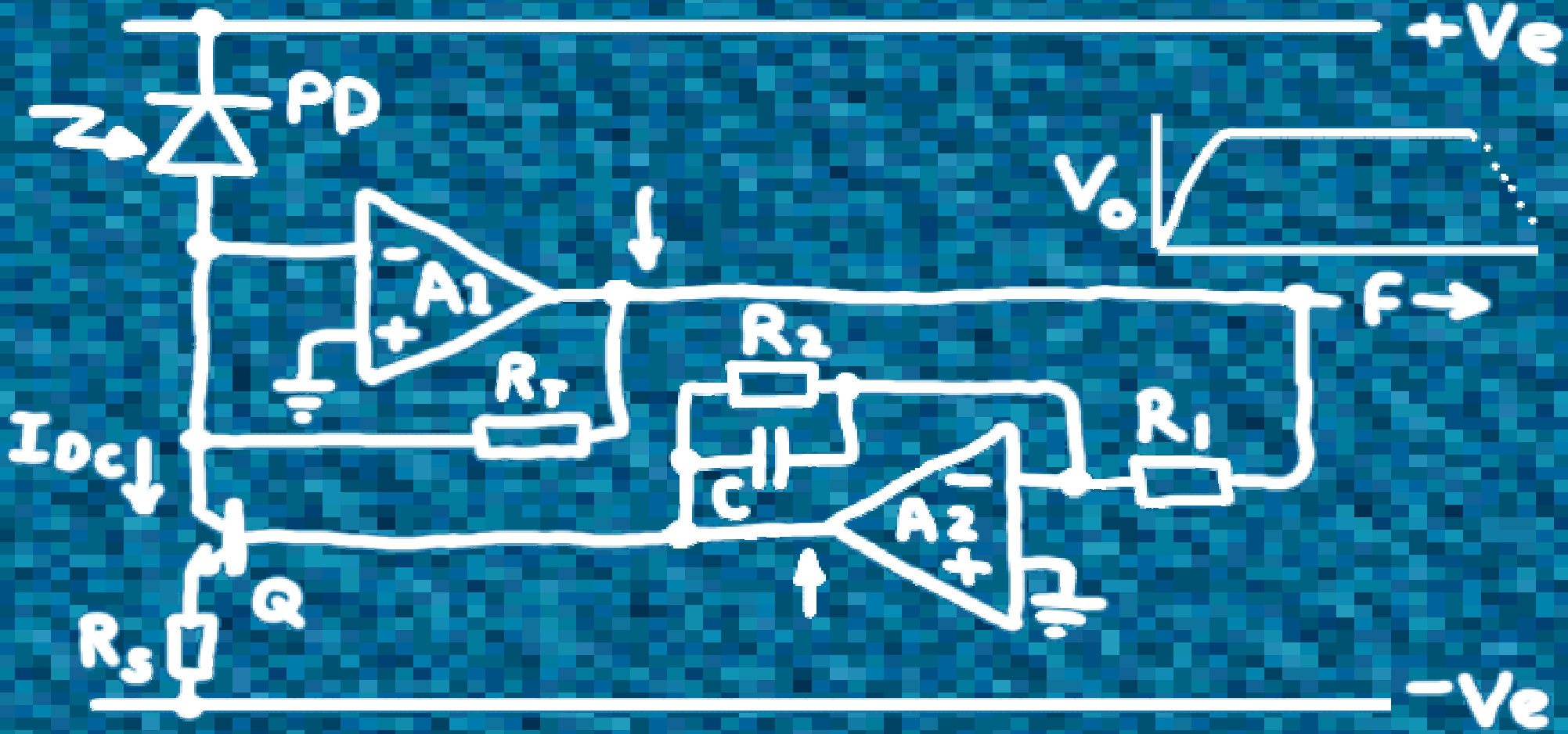
The line is shorted but appears open circuit at f=λ/4 where all the PD current goes to the amplifier input — C can be made large and Ls is made adjustable to position the corner peak

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



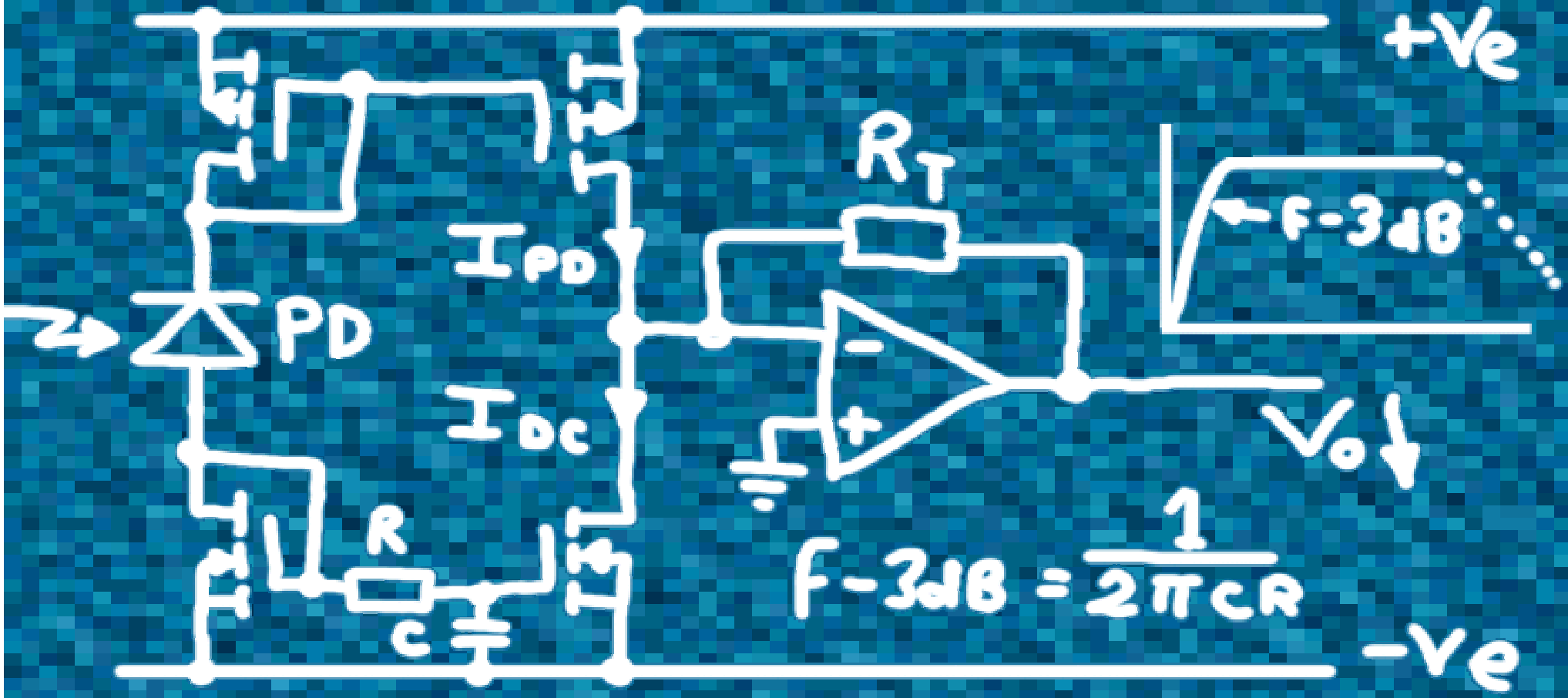
Gain ranges are set by resistor R_T which converts the PD current to a voltage $V_o = I_{PD} * R_T$ — The circuit on the left inverts the signal and will be used in the following examples …

Integrator A_2 amplifies the low frequency components of Vo — 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 -3dB 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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