POWER SUPPLY

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Questionnaire

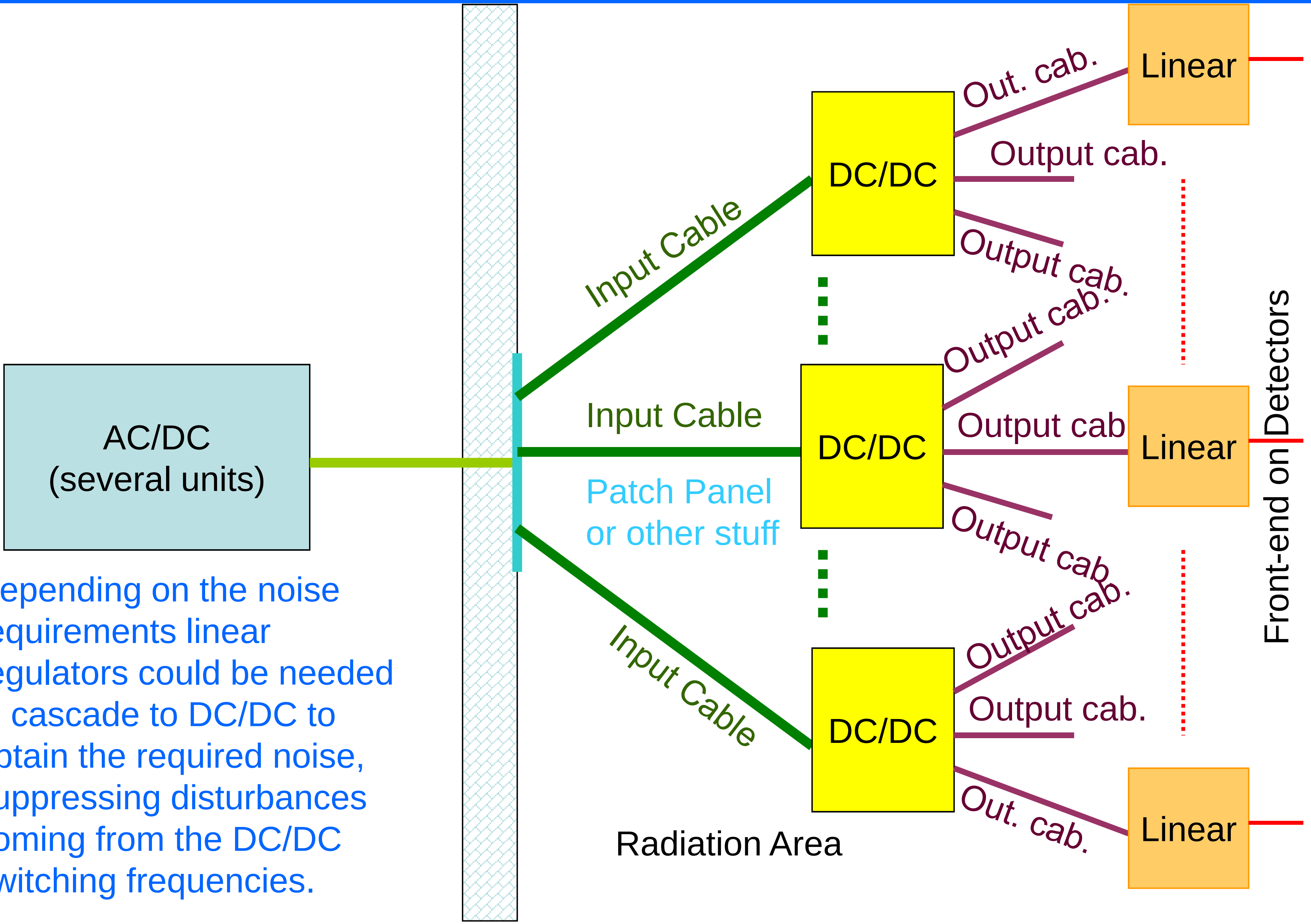
So far the questionnaire has been answered only by Angelo Cotta Ramusino and Mauro Villa.

DC/DC power Supply						
	V1	V2	V3	V4	V5	Comment, if any
Required Voltage level (V)						
Total power (W)						
Number of input connections/cables						
Current absorption per input cable						
Number of output connections/cables						
Current absorption per ouput cable						
Purpose (pre-regulation followed by linear regulator, final value, etc.)						
Power supply location (detector area, outside detecotr area)						
Maximum ripple (mV), or						
Maximum ripple (%)						

HV for detectors bias						
	V1	V2	V3	V4	V5	Comment, if any
Required Voltage level (V)						
Total power (W)						
Number of input connections/cables						
Number of output connections/cables						
Power supply location (detector area, outside detecotr area)						
pp noise (mV), or						
pp noise (%)						

Some thought about power supply layout…

The conventional approach (1)

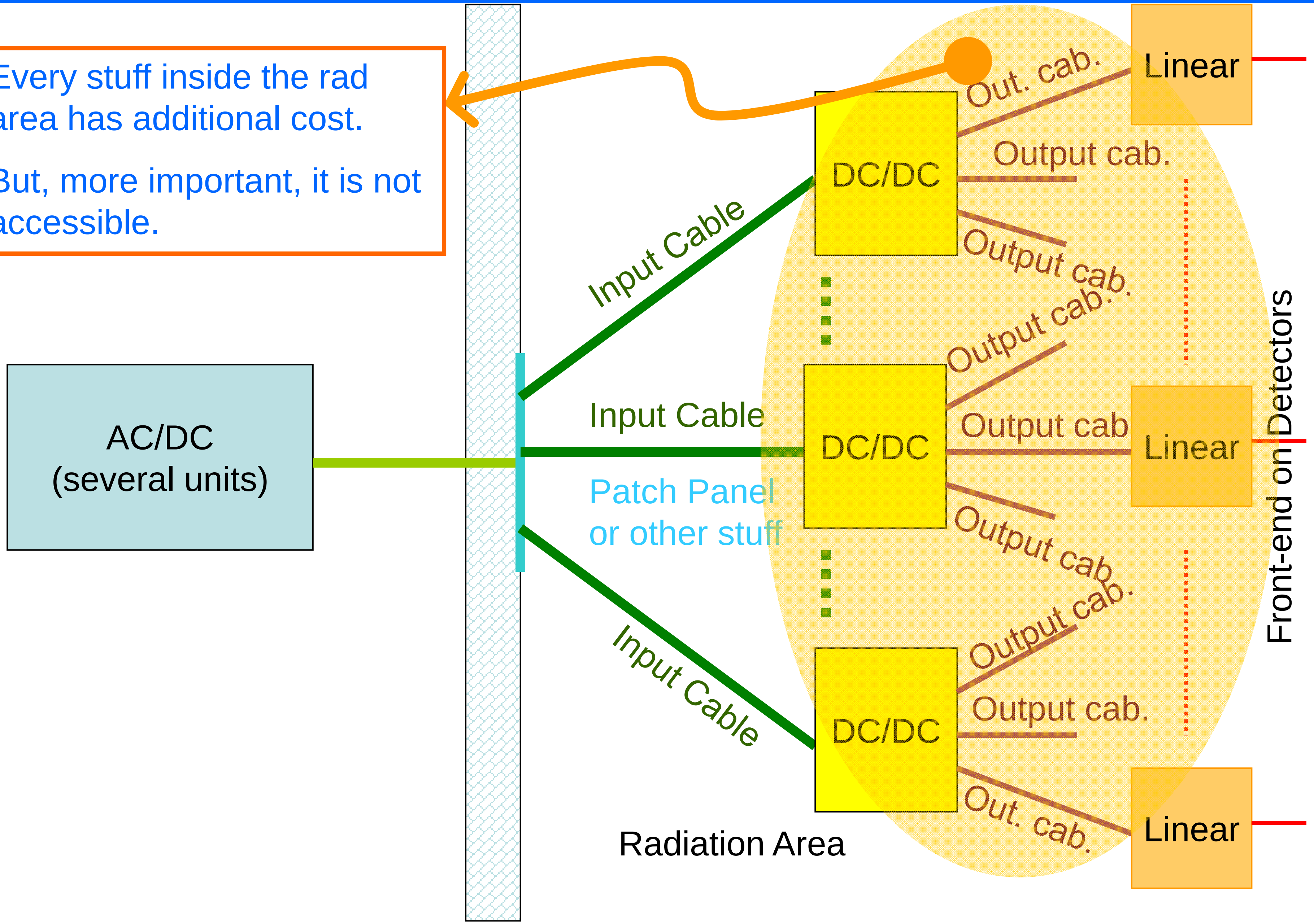


Depending on the noise requirements linear regulators could be needed in cascade to DC/DC to obtain the required noise, suppressing disturbances coming from the DC/DC switching frequencies.

The conventional approach (2)

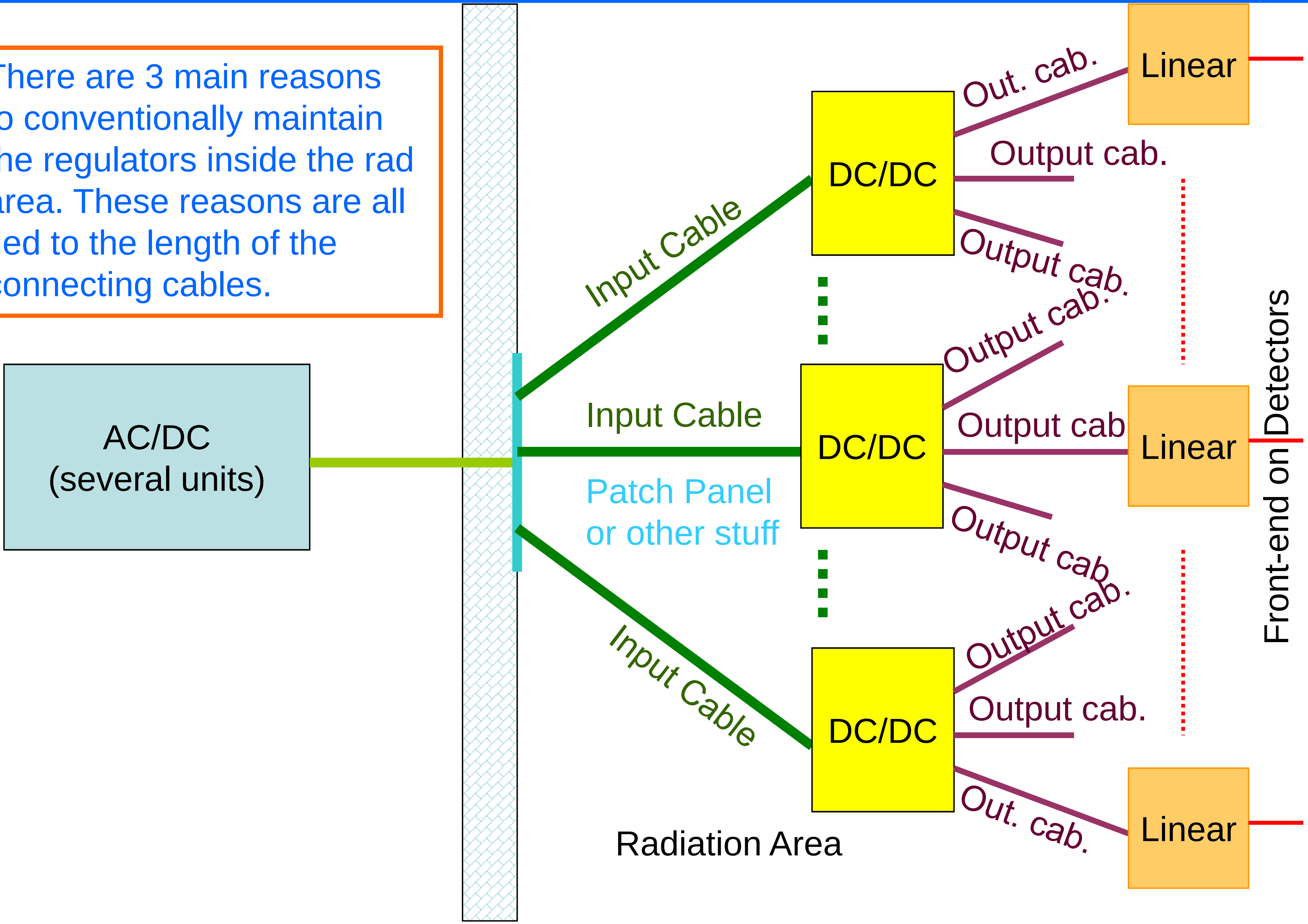
Every stuff inside the rad area has additional cost.

But, more important, it is not accessible.



The conventional approach (3)

There are 3 main reasons to conventionally maintain the regulators inside the rad area. These reasons are all tied to the length of the connecting cables.

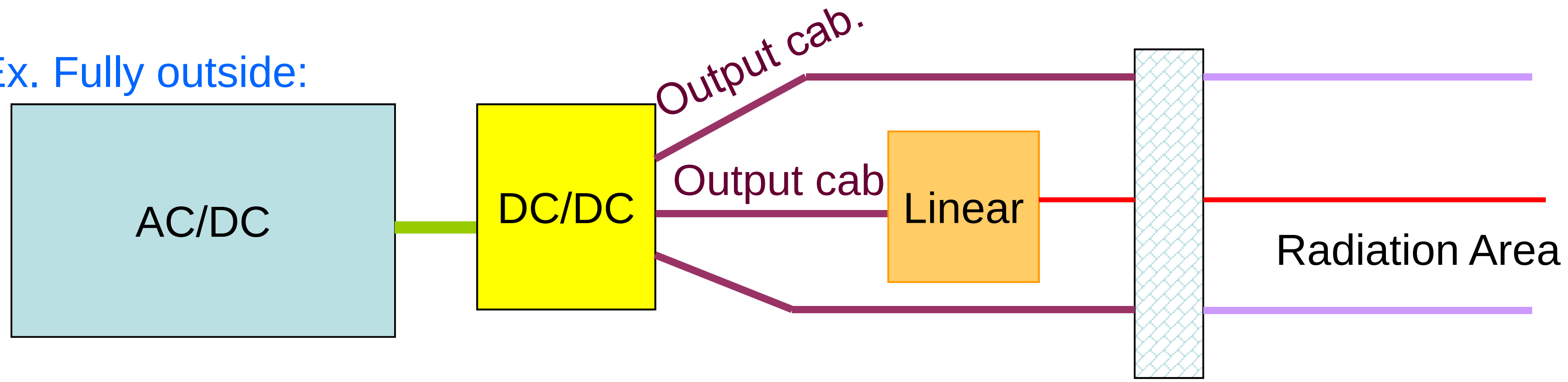


The un-conventional approach

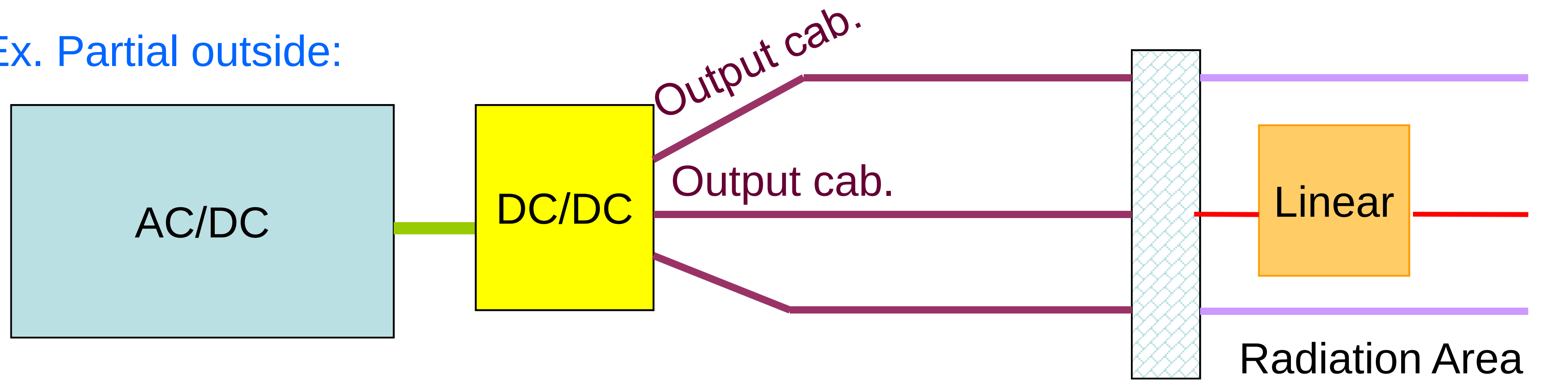
A more simple approach is to avoid the presence, or minimize the number, of voltage sources inside the rad area. Especially the DC/DC sources.

Maintenance in this way is easy to do and cheaper solutions are available on the market.

Ex. Fully outside:

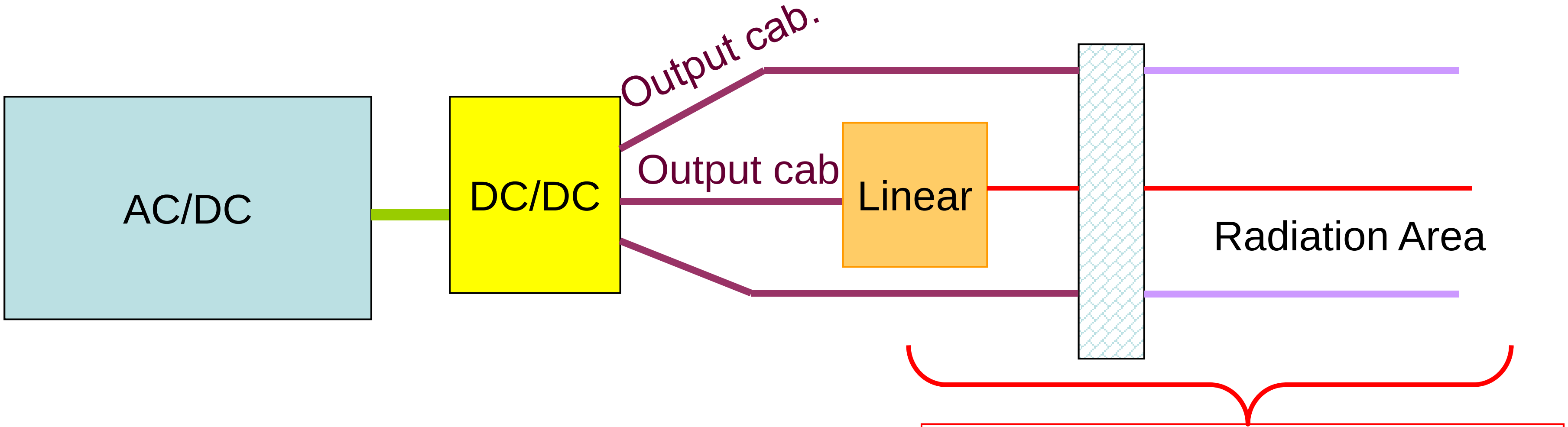


Ex. Partial outside:

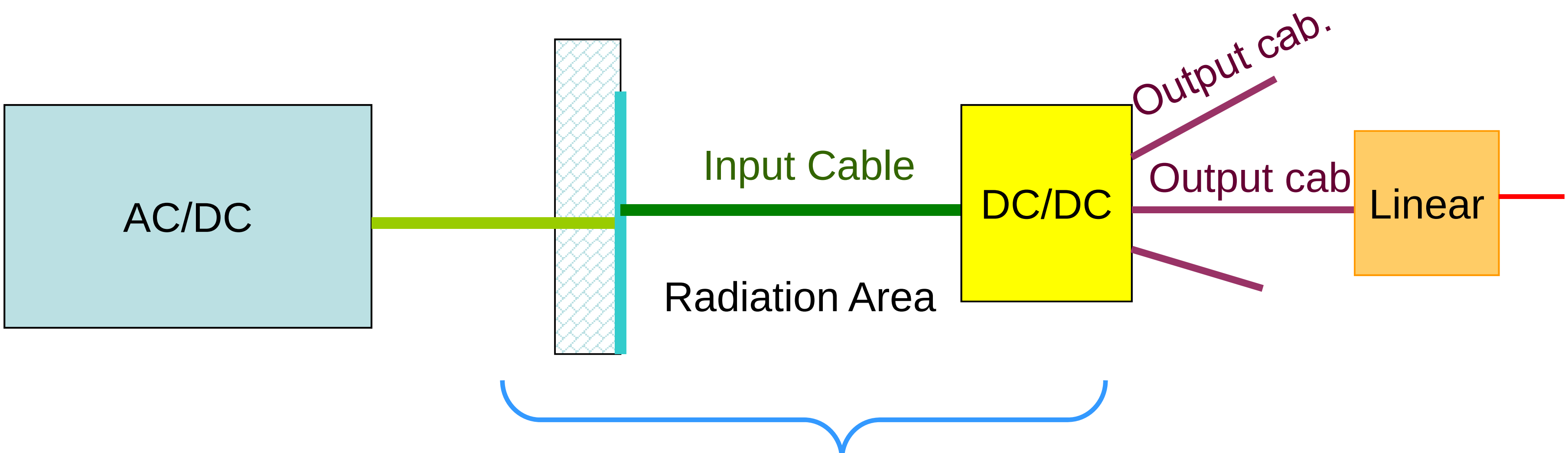


Let's verify the reasons this solution is generally not pursued and how to try to get rid of this.

The conventional approach (4)

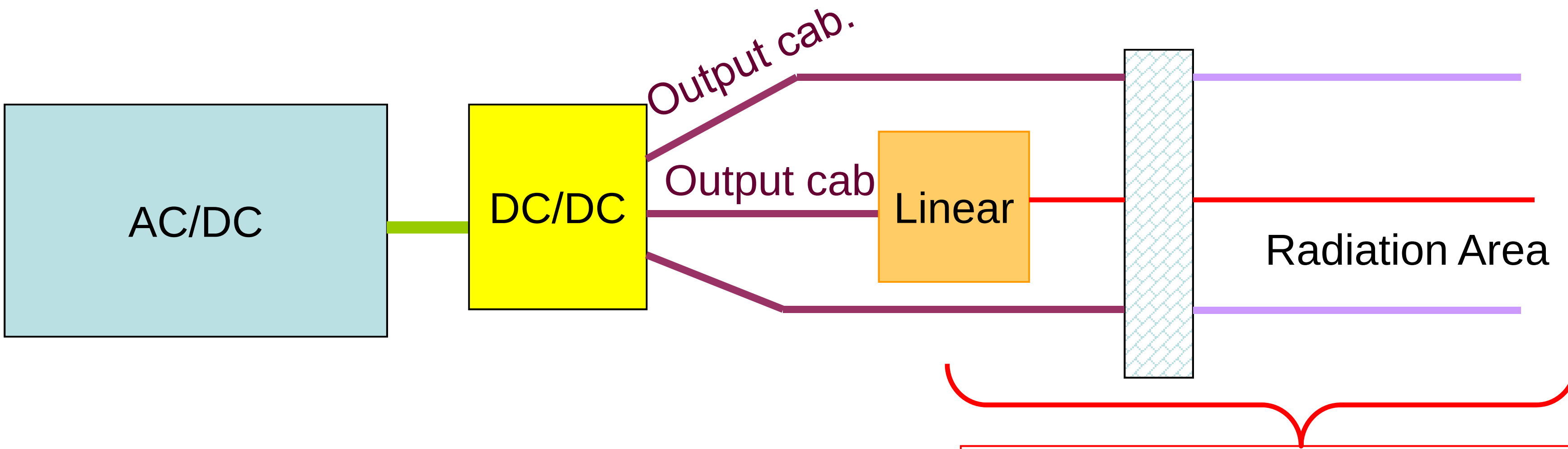


If the cables are long they can pickup EMI disturbances.



Cable pickup is filtered at the DC/DC input in a conventional approach.

Pickup attenuation



If the cables are long they can pickup EMI.

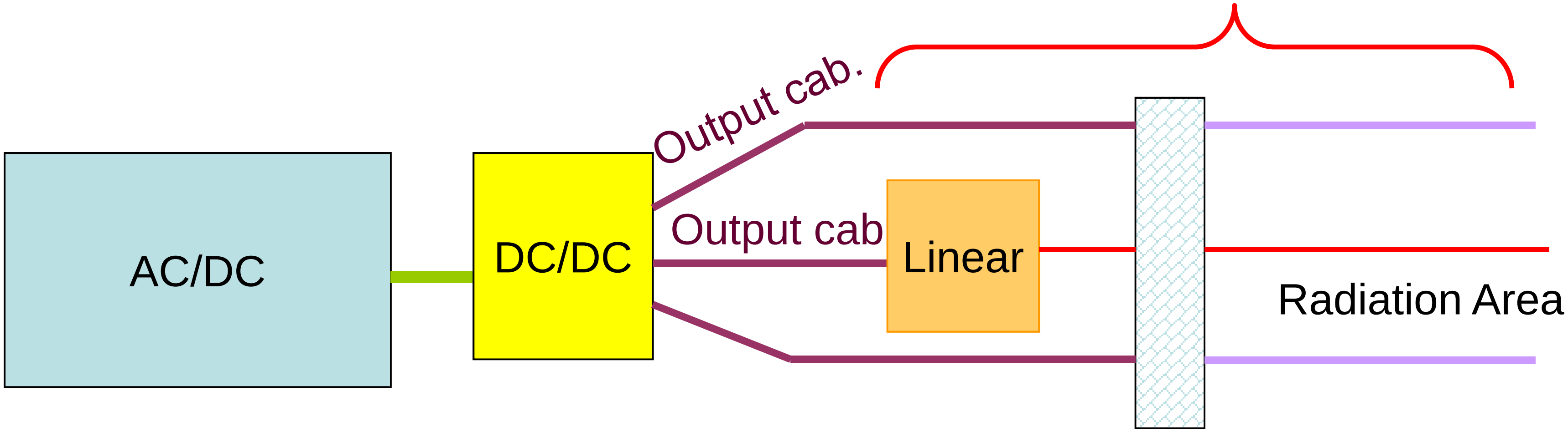
Pickup is greatly attenuated if the cables are shielded.

We normally do this even for standard cord-cables.

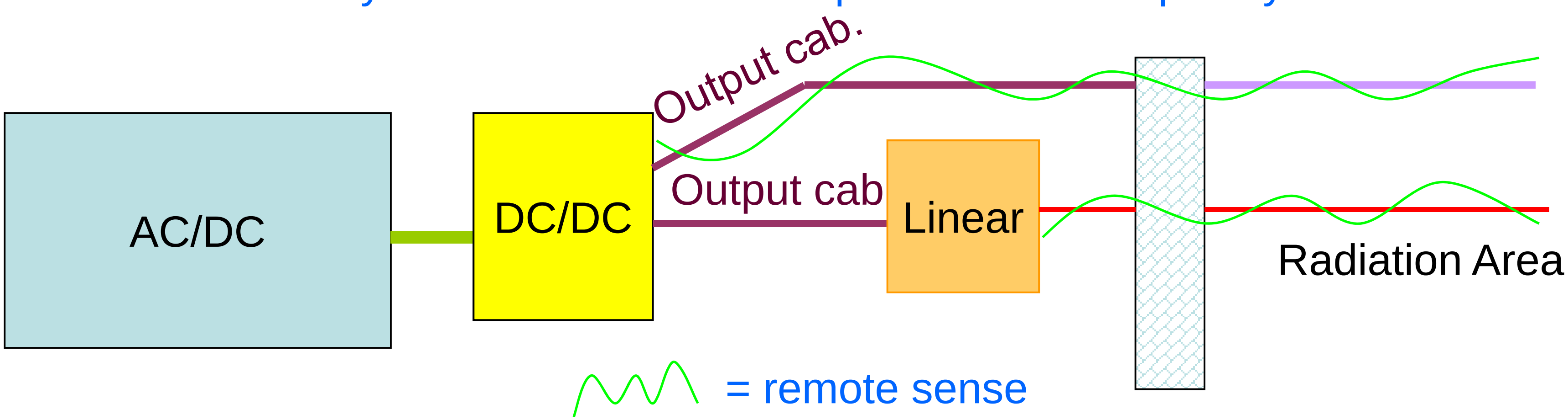
See later for results.

The conventional approach (5)

Across the length of the cable a voltage drop is present which come from the series resistance of its conductors.



The voltage drop-out across the cables can be compensated for by remote sensing.
The lost of efficiency can be small if current per cable is adequately small.

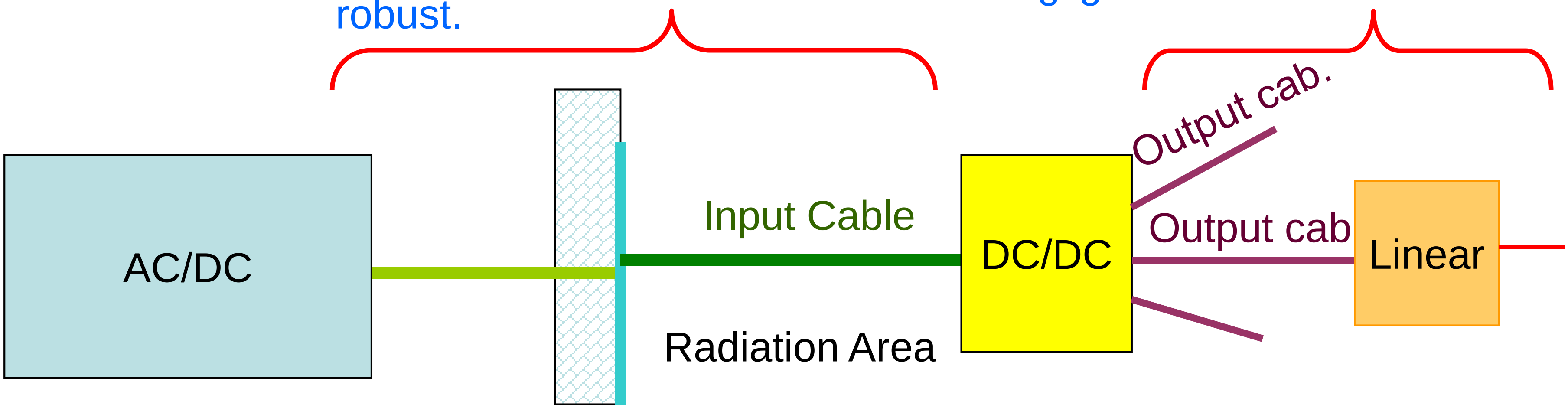


The conventional approach (6)

Accidentally short circuits are the main cause of troubles. Cables show an inductive component in their impedance. This inductance can rise the voltage level at the cable end after the recovery from a short circuit. This voltage increase can create damage to the connected electronics. The conventional way to solve this is to locate the regulator close to electronics in order to minimize this stray inductance:

Short circuits here do not create problems since the DC/DC is robust.

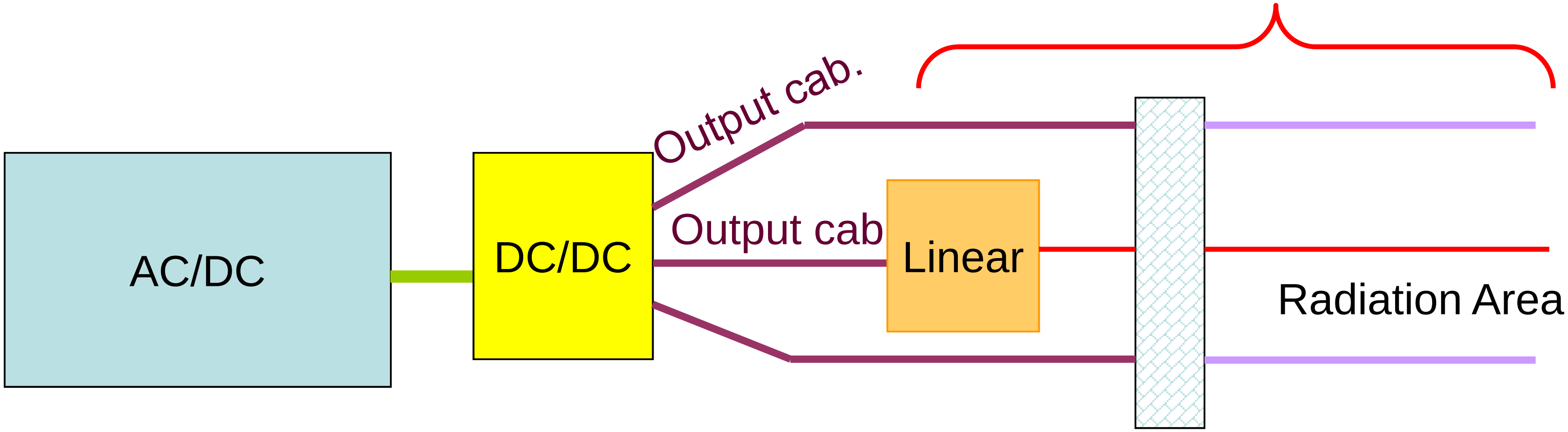
Cables here are very short and their inductance is negligible. After the recovery from a short circuit the voltage increase is negligible.



Toward the un-conventional approach (1)

We propose an approach to avoid troubles with overvoltage in case voltage supplies are located outside the rad area:

Cable length in this case can be 10’s of meters length



Toward the un-conventional approach (2)

To test, we got 30 m of conventional cable composed of units of 5 m length. The composition was hybrid, just because the availability was that: some pieces had sections of 1.5 mm^2, some other 2.5 mm^2.

Inductance of the pair would satisfy:

$$L_{wires} \approx \frac{\mu_0 \mu_r}{\pi} \cosh^{-1}\left(\frac{s}{d}\right) \cdot L$$

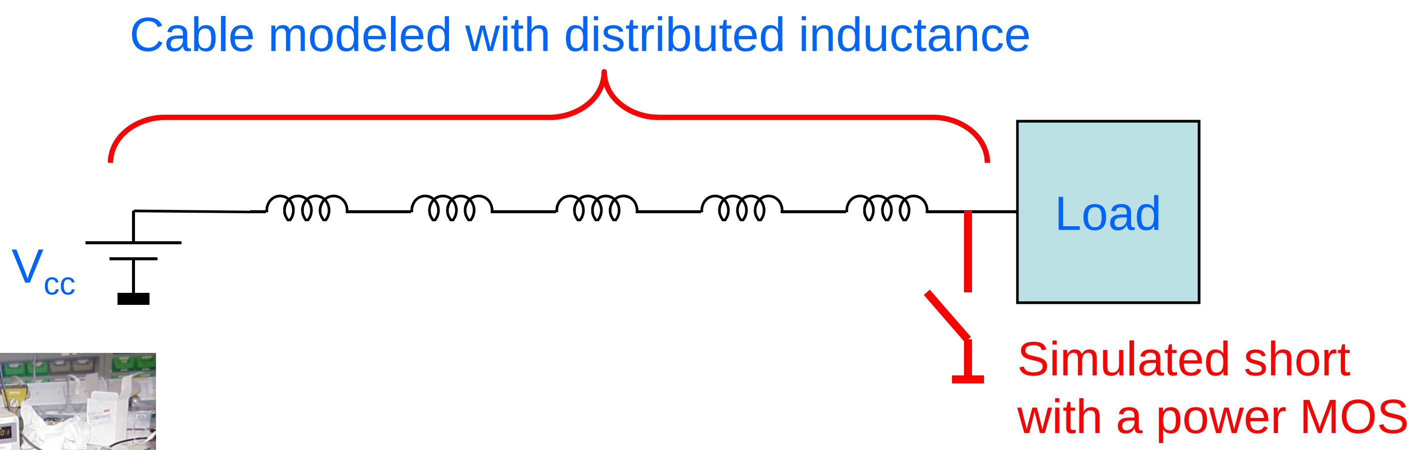
and it is expected to be almost constant for 1.5 mm^2 and 2.5 mm^2 since the pair mutual distance is proportional to the section.

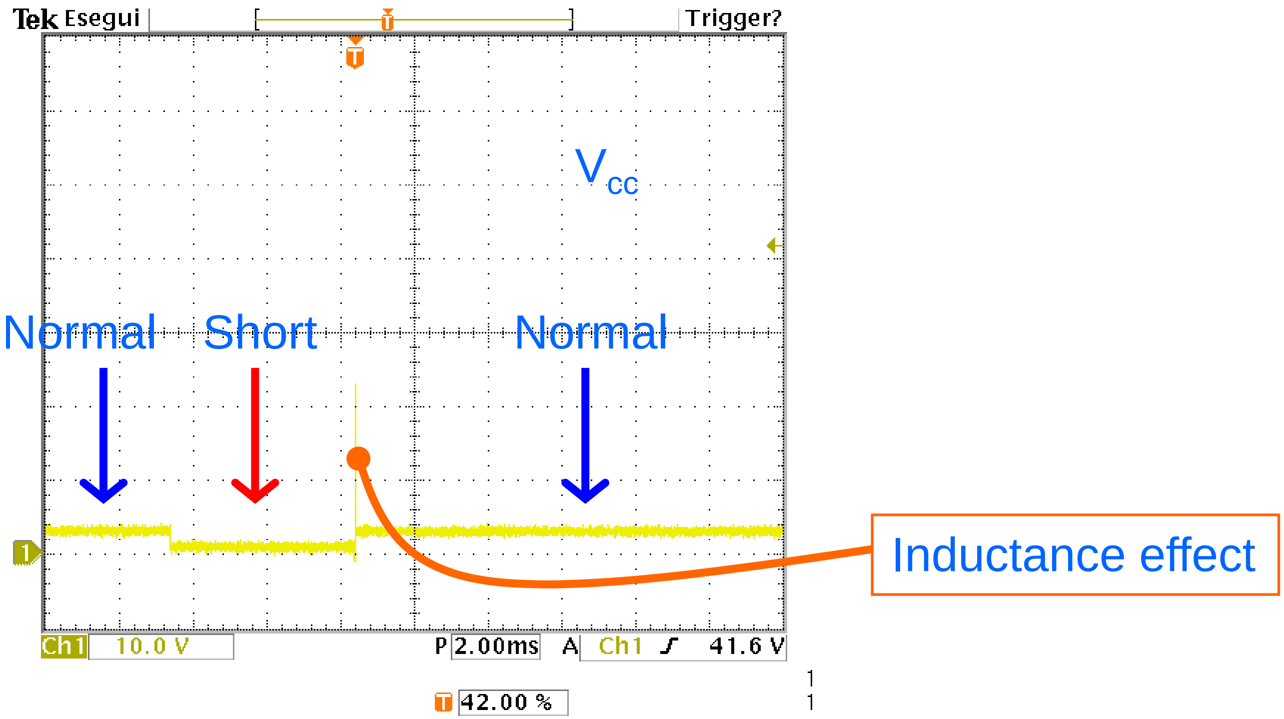
So far we measured:

20 μH for the whole 30 m cable from DC to about 800 KHz; from 800 KHz to 1 MHz the inductance increased to 36 μH.

Measuring each sections we got about:

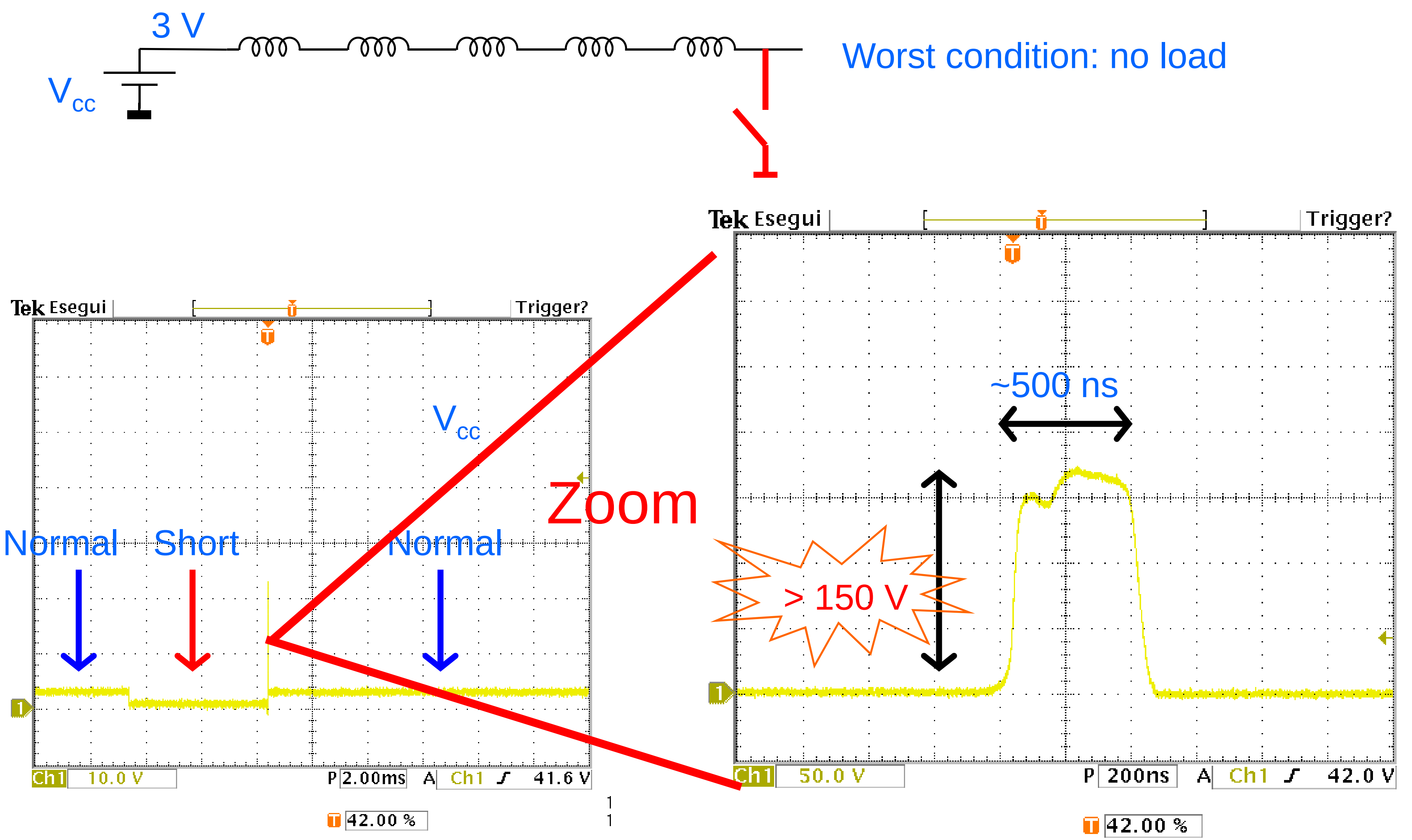
0.65 μH/m for frequencies smaller than 800 KHz.



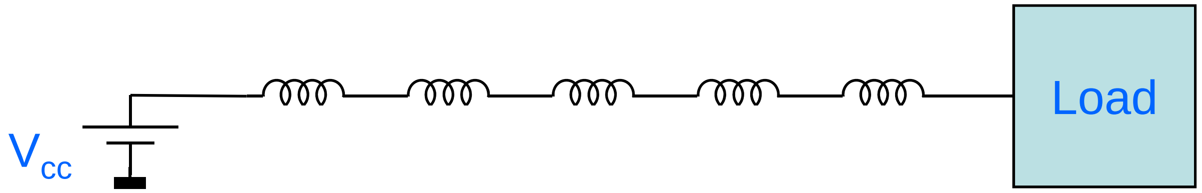


V_{cc} was set to 3 V in this example.

Toward the un-conventional approach (4)



Toward the un-conventional approach (5)

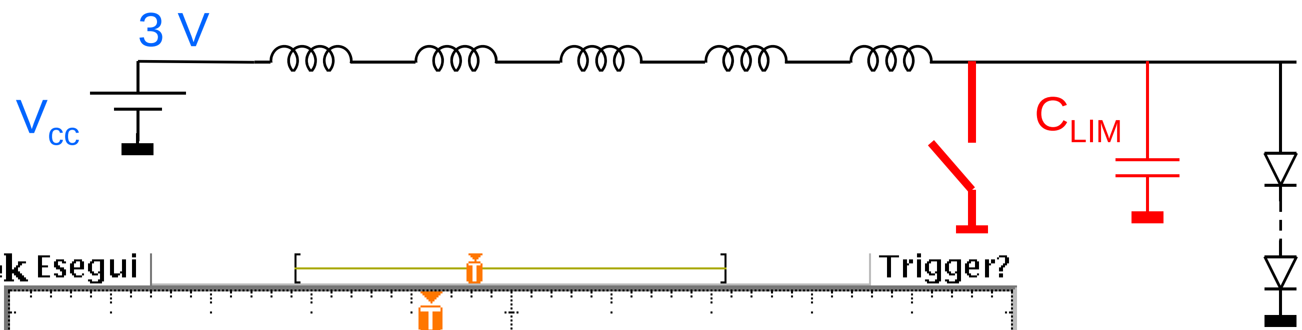


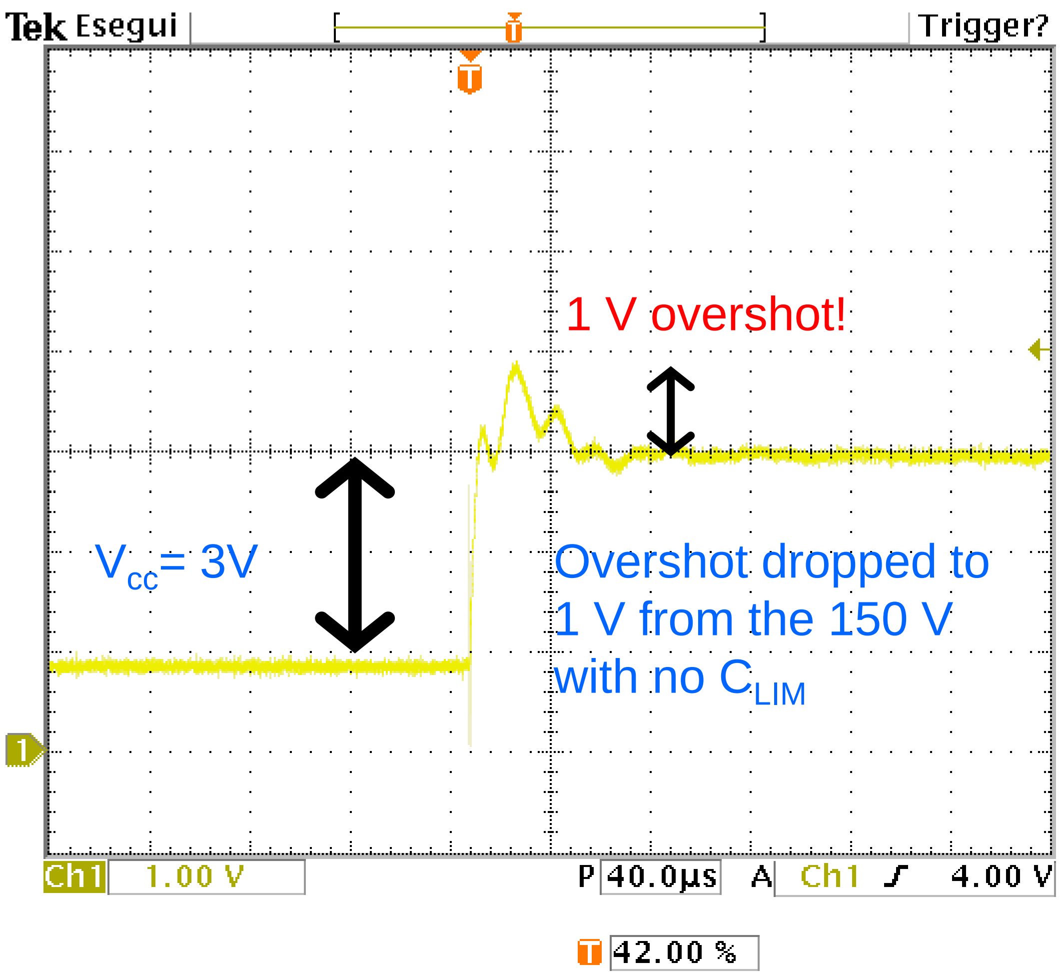
Recipe to minimize overvoltage after shorts:

1. Limit the maximum energy storable in the cable. We normally work at about 33 μJ/m, or 10 A maximum short current. As an example with 30 m cable the maximum energy is about 1 mJ;
2. Terminate the cable with a capacitance of proper value, such that if V_{MAX} is the maximum allowable voltage it is satisfied that:

$$\frac{1}{2} C_{LIM} V_{MAX}^2 \geq \frac{1}{2} L_{cable} I_{short}^2$$

$$C_{LIM} \geq L_{cable} \left(\frac{I_{short}}{V_{MAX}} \right)^2$$

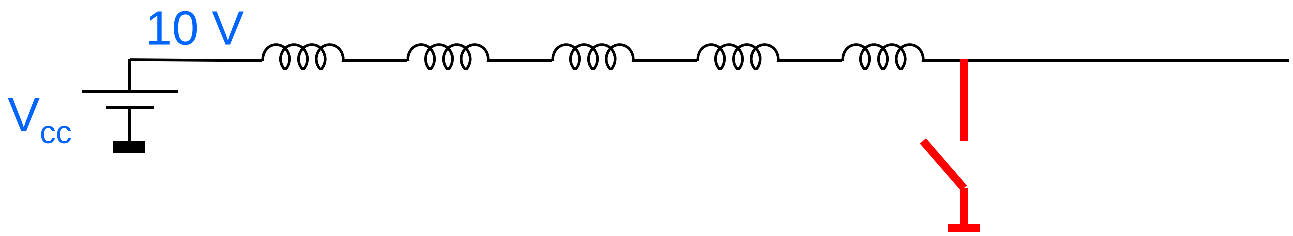


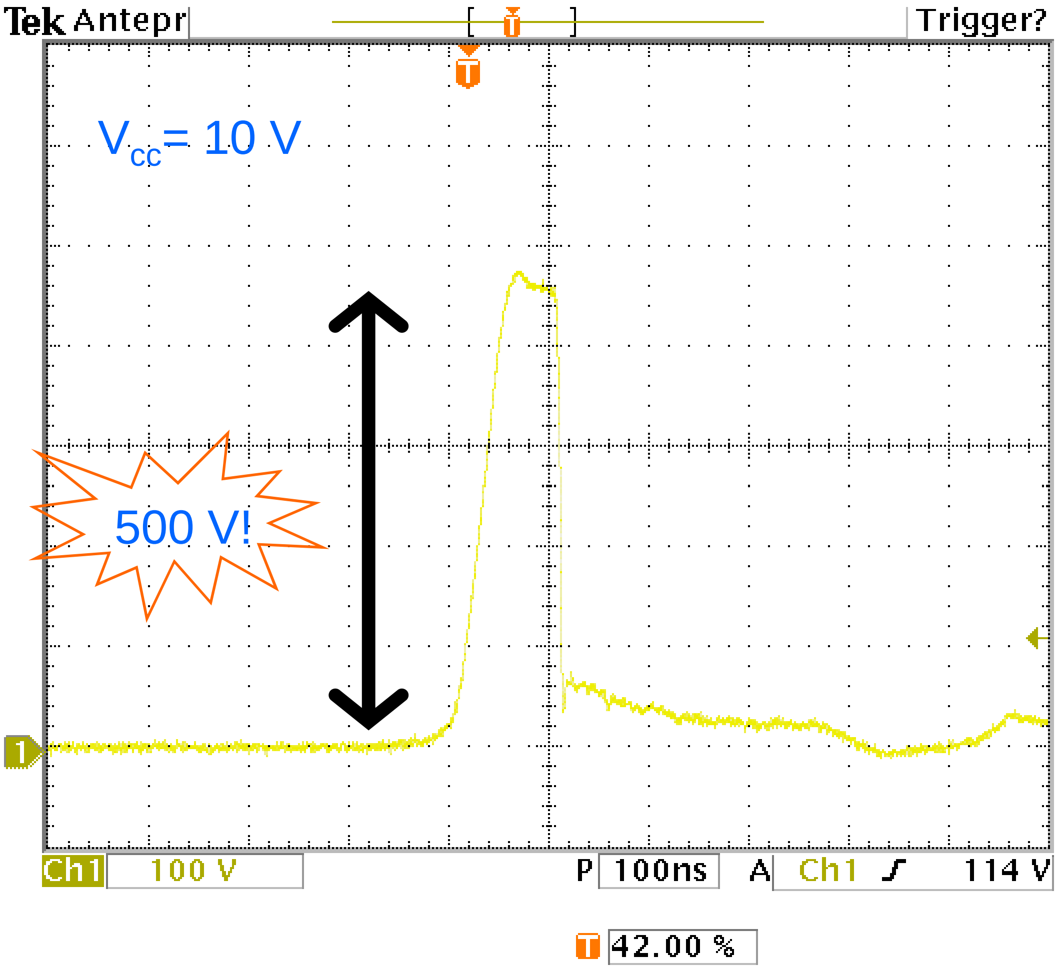


Conditions:
30 m cable lenght (20 μH)
C_{LIM}= 6.6 μF
5 x MUR460 diodes to dissipate energy

V_{cc}=3 V
Short circuit current was about 2.5 A, limited from the series resistance of the cable (~ 0.8 Ω)

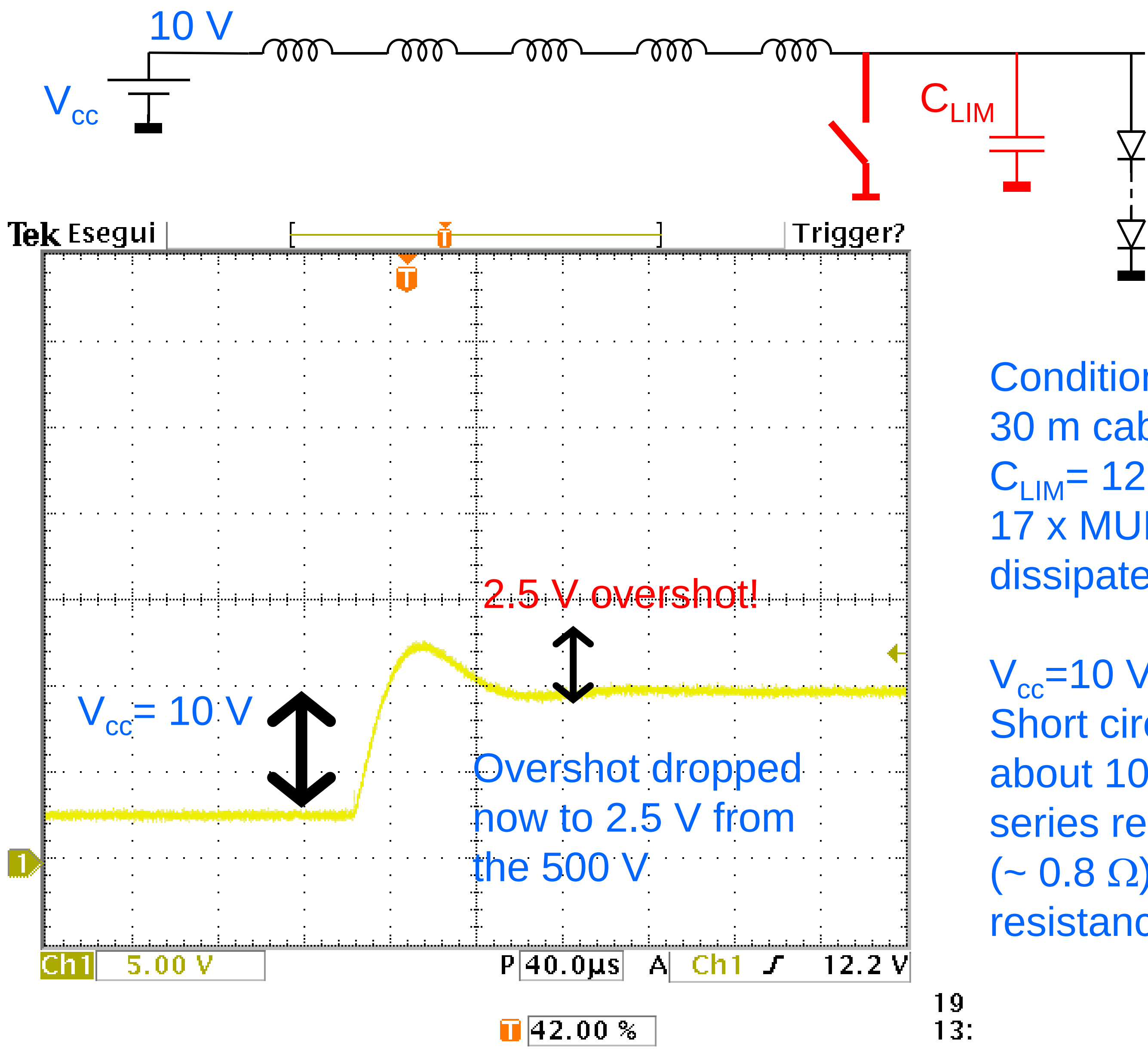
Toward the un-conventional approach (7)





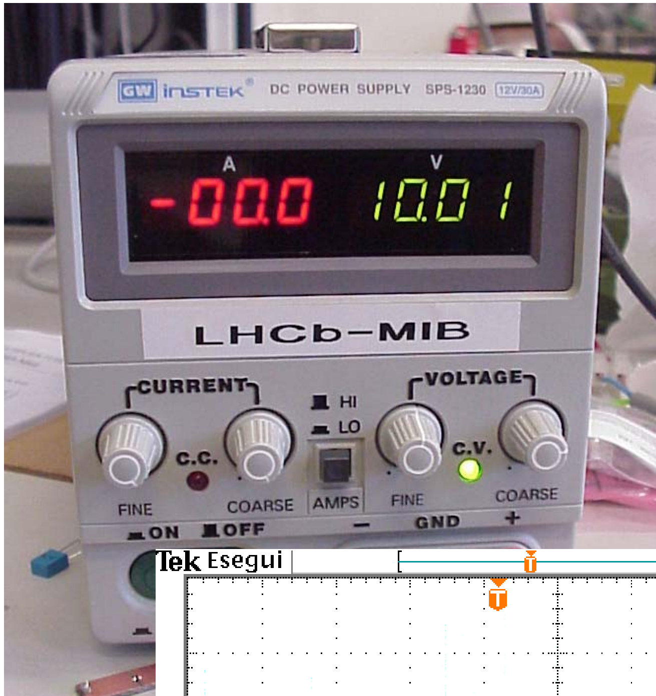
Un-managed condition and no load.

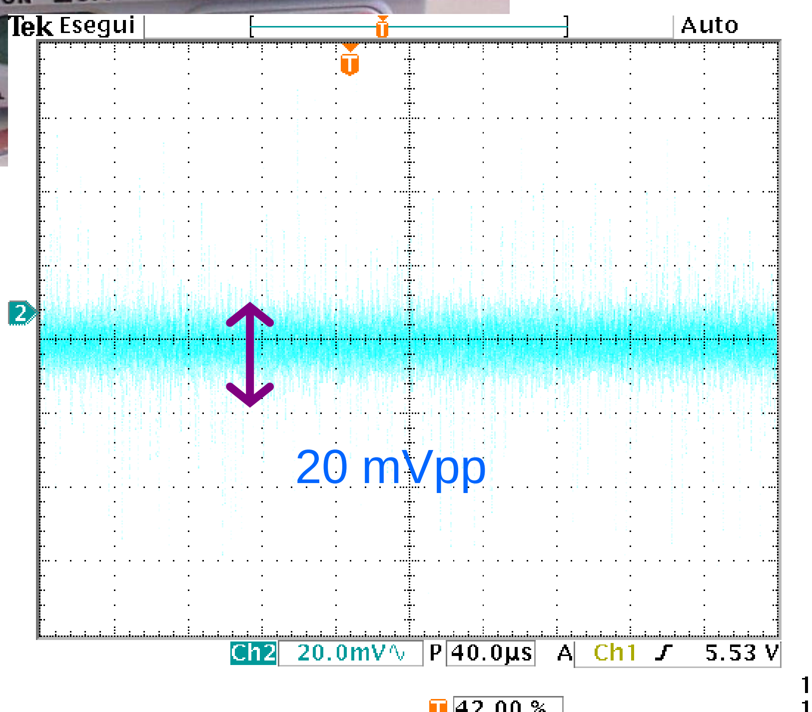
Toward the un-conventional approach (8)



Conditions:
30 m cable lenght (20 μH)
C_{LIM}= 12 μF
17 x MUR460 diodes to dissipate energy

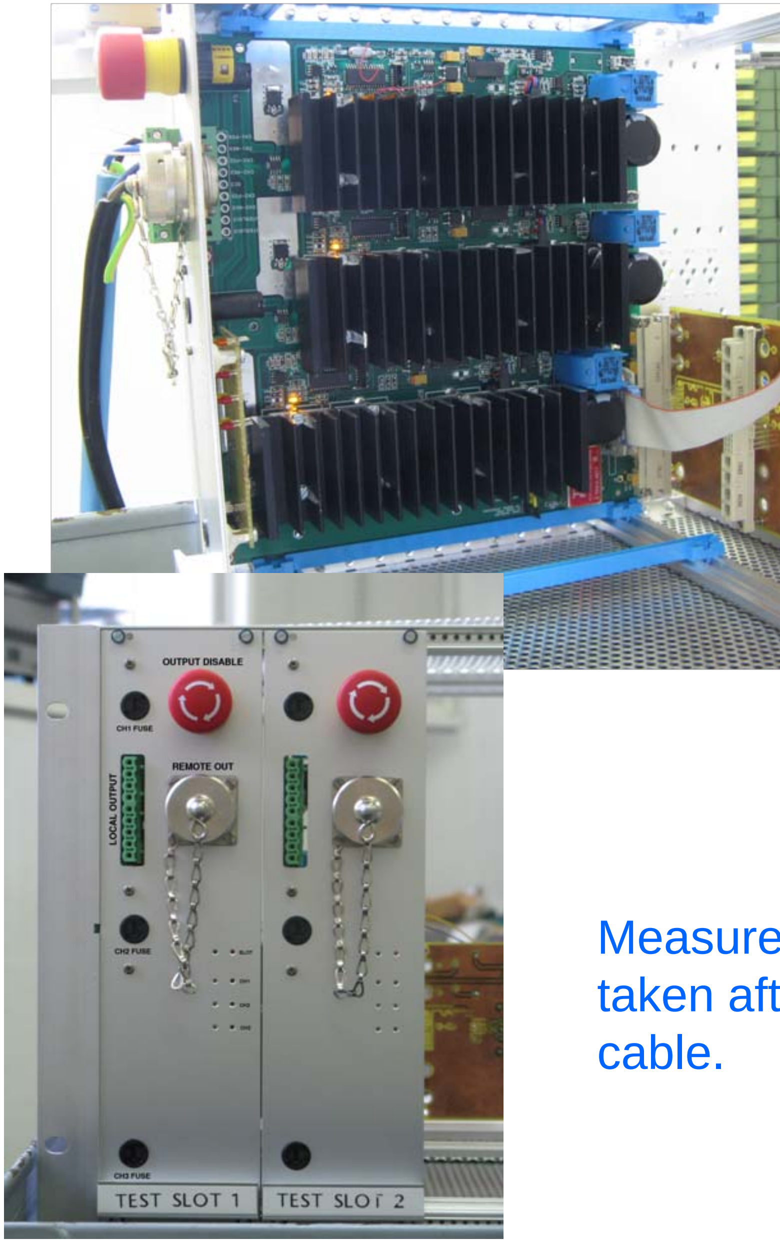
V_{cc}=10 V
Short circuit current was about 10 A, limited from the series resistance of the cable (~ 0.8 Ω) and the on MOS resistance used.



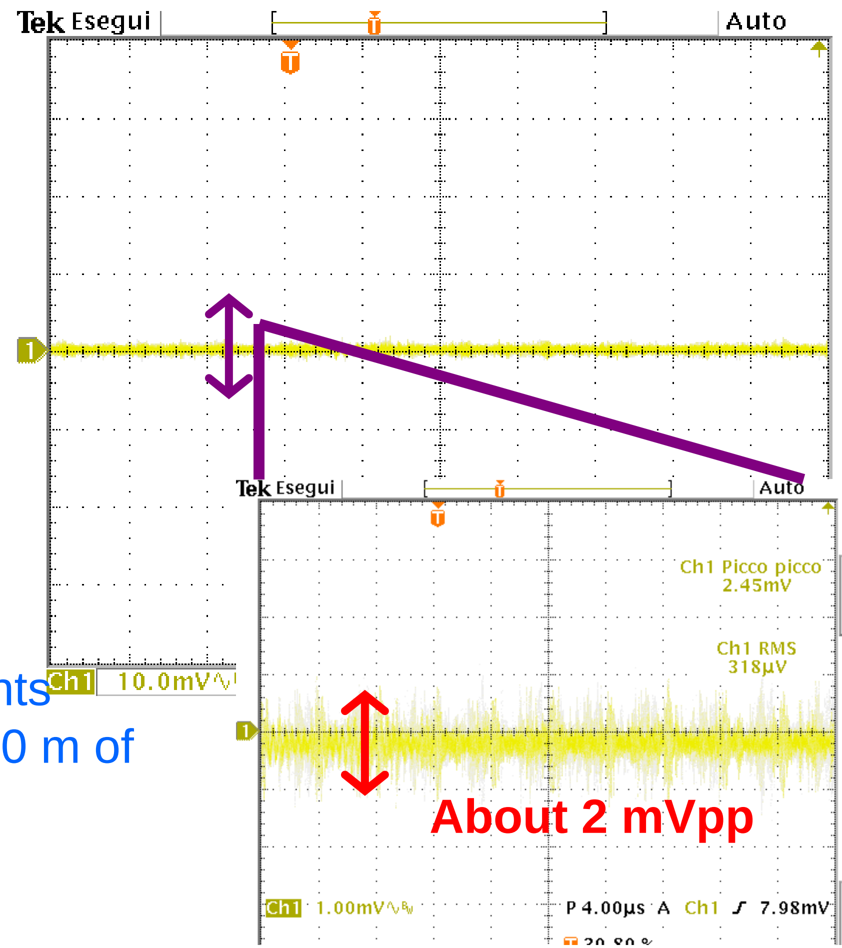


Limiting the handled current per cable allows to employ very cheap and commercial power supplies.

The limiting characteristics of these units could be the noise.

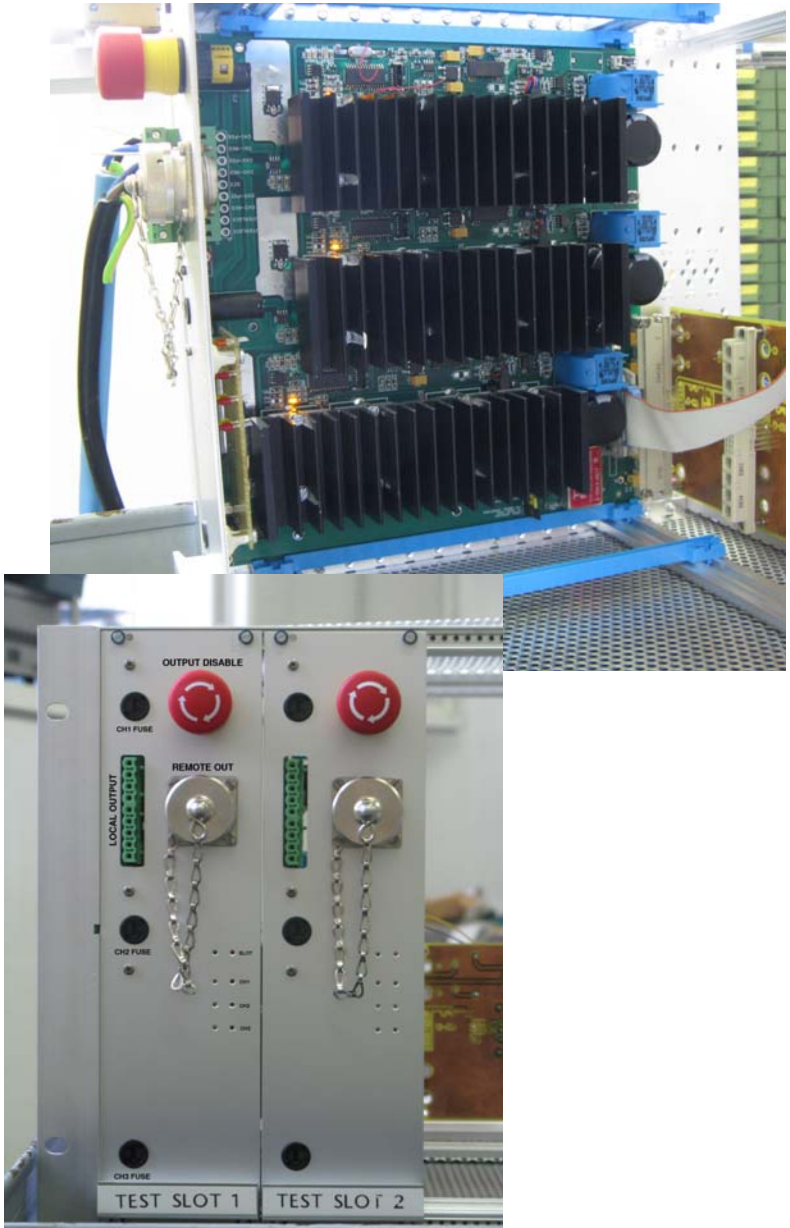


We have developed a DC/DC programmable unit which has very low noise, comparable to a linear voltage supply:



Measurements taken after 30 m of cable.

Toward the un-conventional approach (11)



Some characteristics of the unit:

- Remote manageable with CAN-bus;
- 3 independent and floating outputs per board;
- Settable output voltage and current;
- Remote voltage level sense

Conclusions

- An approach to manage long connecting cables to power supply in safe mode was tested;
- It allows to avoid the presence of power supplies units in the detector area.

SPARE

Our custom Supply after a short

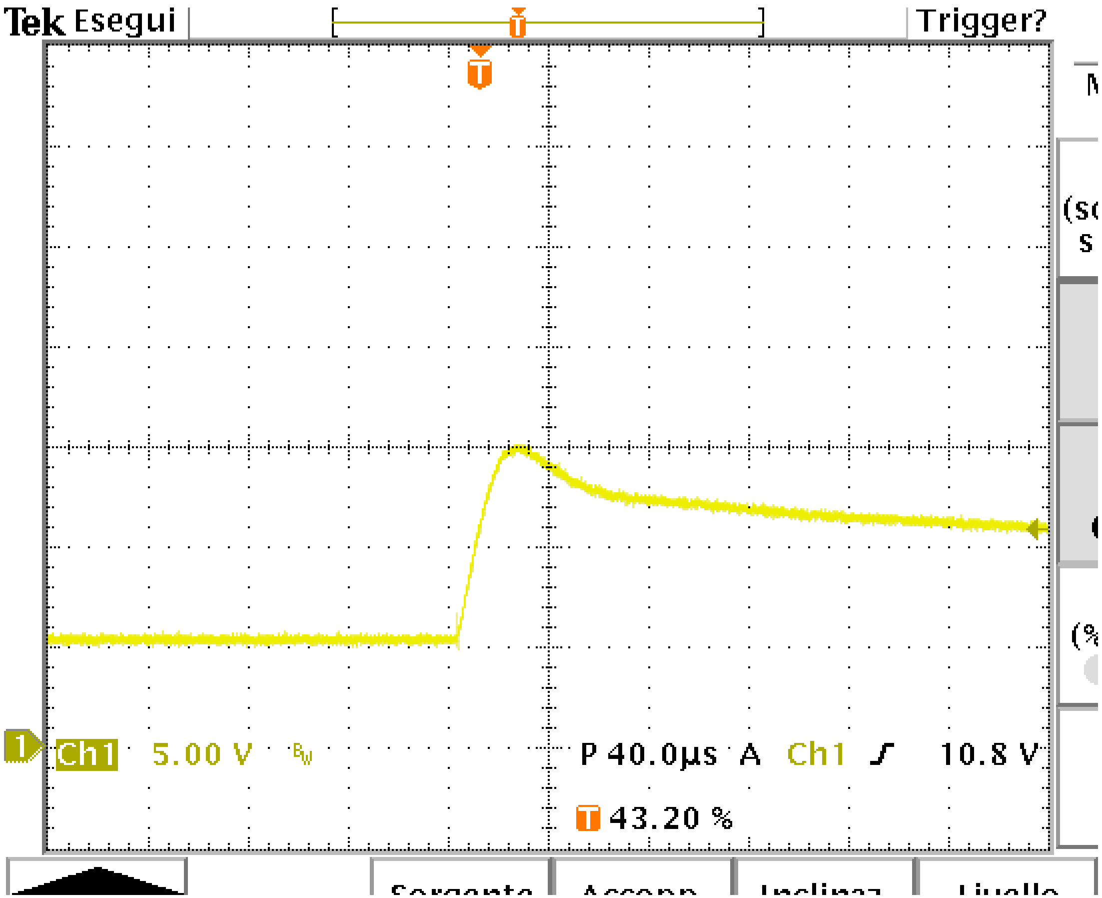
Cable length: 30 m;

V_{cc}= 10 V;

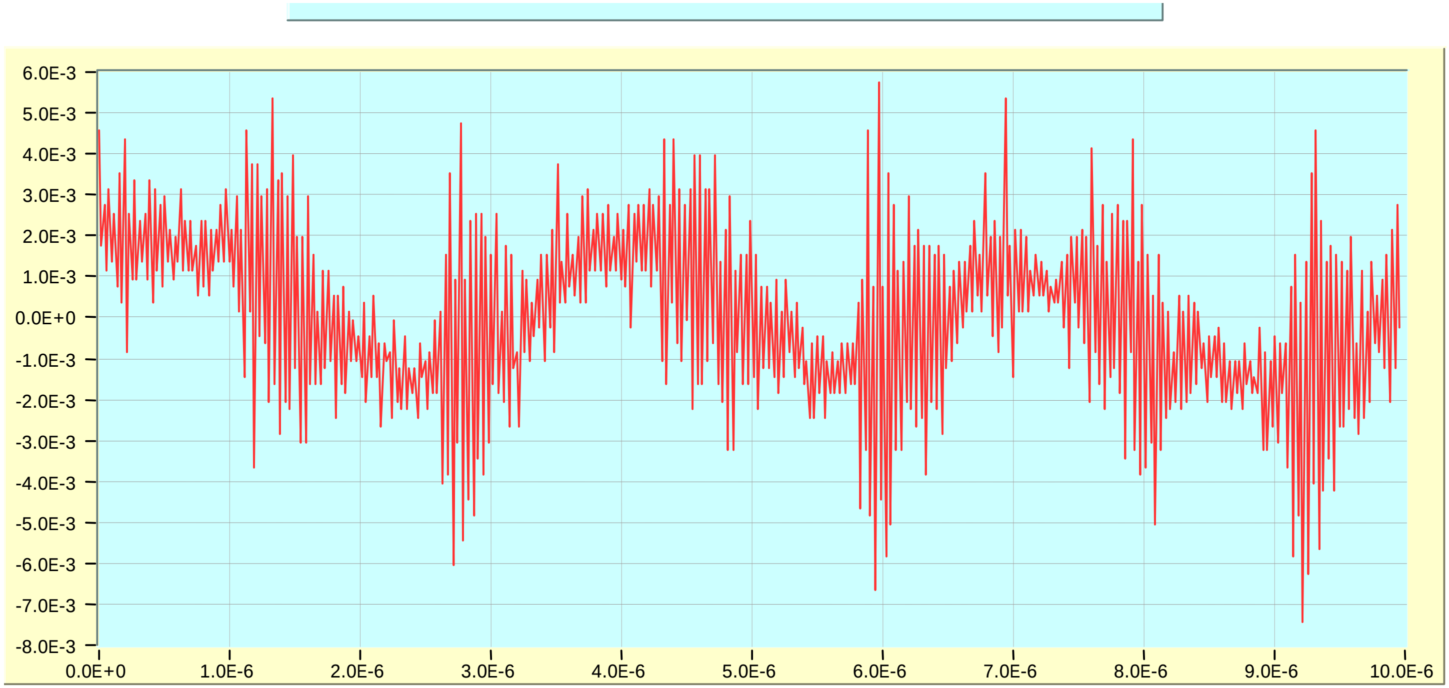
3.3 Ω simulated load;

C_{LIM}= 12 μF

No diodes to discharge

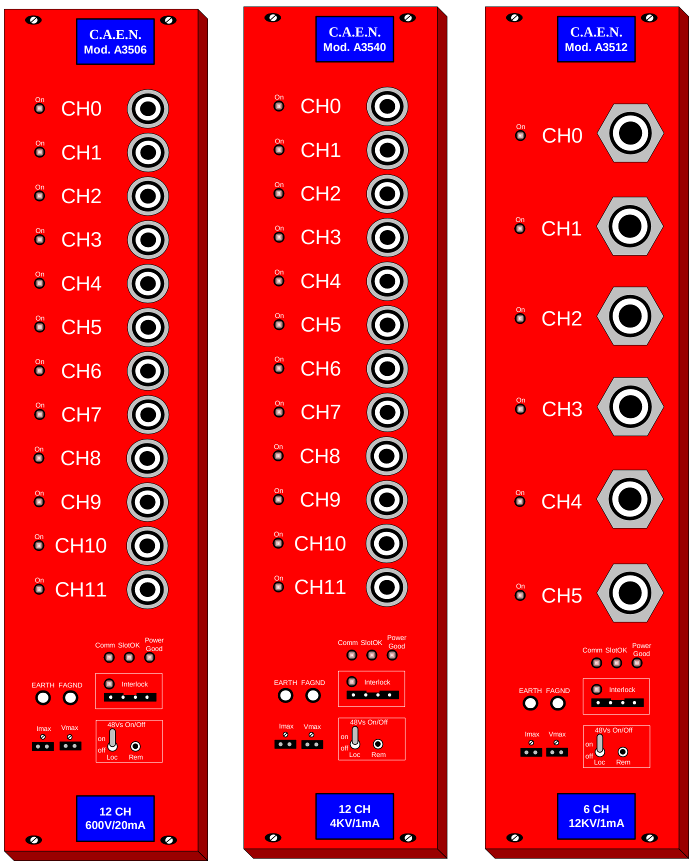


Noise from Wiener



Noise from CAEN

A3506 - A3540 – A3512



- Polarized Floating Channels
- VMon and VSet accuracy

  (A3540 & A3512) +/- (2V + 0.1% Iout)
  (A3506) +/- (1V + 0.1% Iout)
- IMon and ISet accuracy

  (A3540 & A3512) +/- (2uA + 1% Iout)
  (A3506) +/- (5uA + 1% Iout)
- Ripple < 100mVpp (10Hz-15MHz)
- VMax & IMax by trimmer per board
- Channel alarms: Over-Voltage, Over-Current, Over-Temperature, Over-Power
- On/off per Ch.
- LDR trimmer on the board panel
- Board enable (interlock)
- 48V Service local & remote on/off
- SHV or CPE(A3512) HV connectors