

Spark protection

LAPP

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Sparks have many different origins:

- Corona effect spark (detector imperfection or dirt) ;
- Raether limit (detector geometry and set-up condition) ;
- High ionisation may cause divergent avalanche by photon feedback effect.

During this breakdown, the gas is so highly ionising that an arc is created between mesh and anode. As front-end electronics are connected to the anodes, the readout chip may be destroyed !

$$C_{mesh}=8 \text{ fF/cm}^2$$

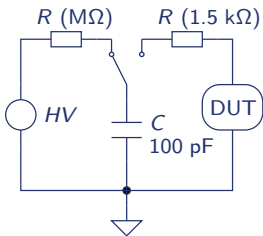
$$\text{If } S_{mesh}=1536 \text{ cm}^2 (32 \times 48), \text{ then } C_{mesh}=12 \text{ nF}$$

$$HV=450 \text{ V}$$

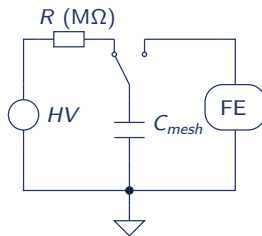
$$Q = C_{mesh} \times HV=5.5 \text{ }\mu\text{C}$$

$$E = \frac{1}{2} \times C_{mesh} \times HV^2=1.2 \text{ mJ (standard HBM ESD protection: } 200 \text{ }\mu\text{J)}$$

Energy is similar, but the current in spark discharges is much higher due to lack of serial resistance:



Human Body Model



Spark discharge

Introduction

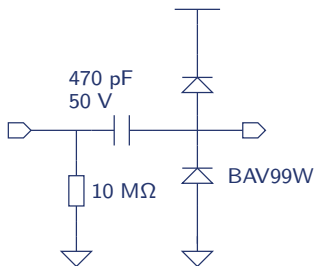
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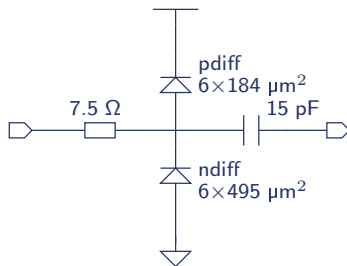
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A lot of schematics to protect form sparks! Two examples:



COMPASS



TOTEM

We must keep in mind: $C_{prot} \gg C_{det}$ (keep signal), but $C_{prot} \ll C_{mesh}$ (to protect).

We must integrate spark protections !

- ILC DHCAL will have from 30 to 50 000 000 channels: no external components allowed!
- Easier fabrication of PCB mask: cost ↓;
- Easier PCB (?) cost ↓;
- Increased reliability

We have still to wonder and propose solutions !

- Resistive oxide on PCB pads ?
- Resistor and capacitor buried inside PCB, diodes inside ASIC ?
- Only a serial resistor and diodes inside ASIC ?

BUT:

Difficult to simulate (which capacitor value, which inductance in net, does the mesh discharge entirely...);

We have to perform **bench** tests to compare protection circuits !

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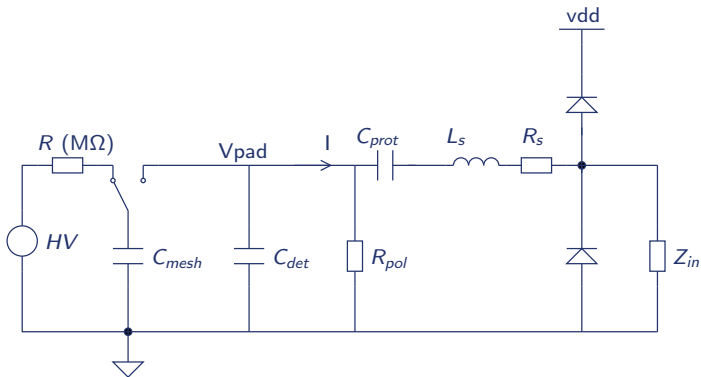
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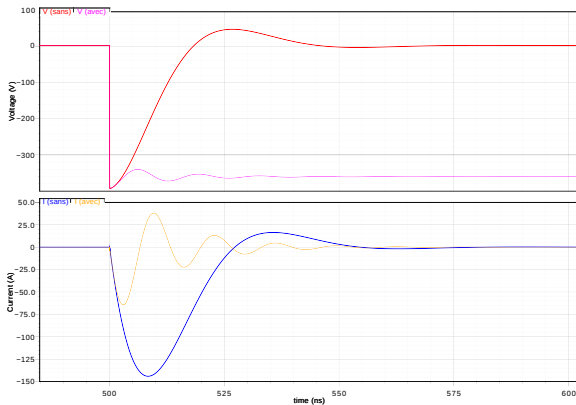
Example (1)

COMPASS (gassiplex) protection detailed schematic ($C_{prot}=470$ pF):



Example (2)

COMPASS (gassiplex) protection simulation:



No arc cut-out in simulation: better model needed !

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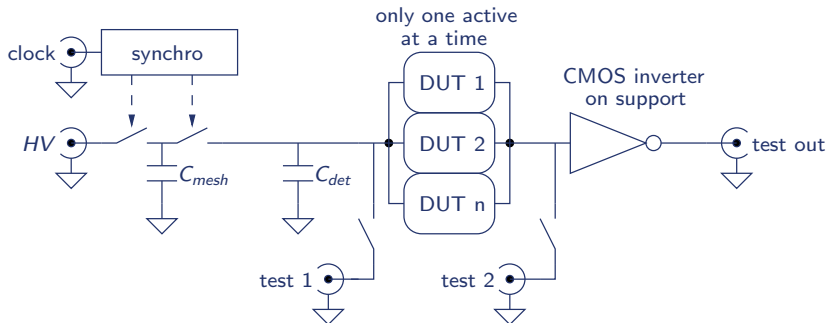
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Idea adapted from E. Noschis *et al.* in *Protection circuit for the T2 readout electronics of the TOTEM experiment*:



Must list different protections to test !

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- *Rendez-vous* with Rui thursday 26/02 to have feedback on embedded capacitors/resistors ;
- We must decide which protections do we want to test ;
- Need agreement to start board design (S. Cap).