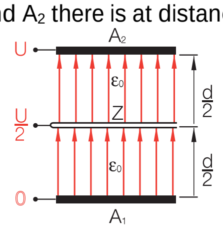
A capacitor ...

... in its traditional form consists of two electrode plates and a dielectric, with a non- or poorly conducting medium in between. The **capacitance $C = \varepsilon (A/d)$,** is determined by **surface A,** the **distance d**, and the **dielectric constant $\varepsilon = (\varepsilon_0 \times \varepsilon_r)$.** ε describes the dielectric constant of this medium.

ε_0 is the absolute dielectric constant of empty space (vacuum).
ε_r is the dielectric number, a (density dependent) material constant.

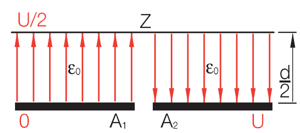
The sensor electrodes ...

... and their effect can be explained using a step-by-step derivation of their geometric shape. The stray fields at the edges of the plates can be ignored for these purposes.
In the middle between two circular capacitor plates A_1 and A_2 there is at distance



d/2 an additional, good conducting, folded „intermediate electrode“ Z with thickness D → 0. An applied voltage between A_1 and A_2 generates an electrical field. This impresses voltage U/2 in electrode Z. The „intermediate electrode“ thereby assumes the function of an additional capacitor plate. This has the effect of changing the capacitor into two geometrically and electrically series connected capacitors.

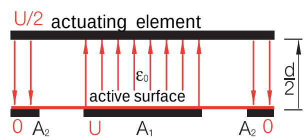
If these partial capacitors are unfolded, plates A_1 and A_2 lie next to each other on one level and the „intermediate capacitor“ Z on a second level at distance d/2. The result is an „open“ capacitor.



The fields in the capacitor halves run in opposite directions.

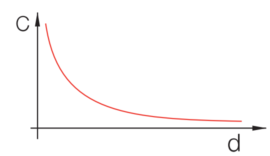
In capacitive sensors ...

... this „open“ capacitor is used as a sensor element. The plate A_2 however is configured as a ring electrode (housing) concentric to A_1 in order to make the electrical field symmetrical, and the „intermediate electrode“ is the „actuation element“. The „active surface“ of this sensor element corresponds to ring electrode A_2.



The formula for capacitance remains – with the above defined premises – valid even for this capacitor geometry.

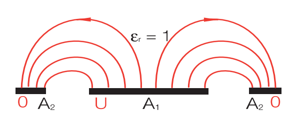
Capacitance C as a function of the distance still decreases hyperbolically (as 1/d).



Non-conducting materials ...

... (plastics, glass as well as liquids) can be detected by capacitive sensors, if ε_r is significantly greater than ε_0; the preceding is based on the fact that for the lines of field, the path of least resistance leads across the actuation element. If the actuation element ($d \rightarrow \infty$; $\varepsilon_r = 1$, $C \rightarrow 0$) is absent, they run in an arc from the middle to the ring electrode. The path of least resistance is thereby also partially determined by the repelling effect of identically oriented lines of field.

The arcs and their distances become greater from inside to outside.



Conditions and correction factors...

If an electrically non-conducting actuation element (target) enters the sensor field, the capacitance changes proportionally to ε_r and to the immersion depth resp. to the distance to the active surface. However it never becomes greater than for metals.

Since the rated switching distance s_n is based on a grounded standard target made of Fe 360, the switching distances must be corrected when using other materials. Correction factors for typical materials are listed in the adjacent table:

Material	Correction Factor
Metals	1.0
Wood	0.2 – 0.7
Glass	0.5
Water	1.0
PVC	0.6
Oil	0.1