Dependent upon the field pattern, the area A through which field line pass perpendicularly is of a different size.

Displacement flux density D

The strength of the electric field is described by the displacement flux density *D* (also known in the literature as electric field density). The displacement flux density *D* is the displacement flux per unit area through which field lines pass perpendicularly. The displacement flux density is determined by the quotient of the quantity of charge on the plates, which in this case corresponds to the displacement flux ψ and the effective area A through which field lines pass:

$$D = \frac{\psi}{A} = \frac{Q}{A} \qquad [D] = \frac{As}{m^2} \qquad (1.8)$$

The displacement flux density is a vectorial quantity and is directly proportional to the existing field strength *E*.

If there is a vacuum between the plates, the flux density can be determined by multiplying the electric field constant and the electric field strength:

$$D = \varepsilon_0 * E \qquad \text{(vacuum as dielectric)} \qquad (1.9)$$

If another insulating material or another dielectric is introduced, the following equation applies for calculating the displacement flux density:

$$D = \varepsilon_0 * \varepsilon_r * E \qquad \text{(arbitrary dielectric)} \qquad (1.10)$$

In case of any other dielectric, the displacement flux density is determined by multiplying the electric field constant ε_0 with the relative permittivity of the respective dielectric ε_r and the electric field strength *E*.

1.8 Capacitor

Capacitor

A capacitor describes every arrangement for storing stationary electric charges. The structure of a capacitor always consists of two conducting surfaces, the so-called electrodes (often termed as sheets). They are always separated from one another by an insulating material, the dielectric. The principle construction of a capacitor is illustrated as follows:

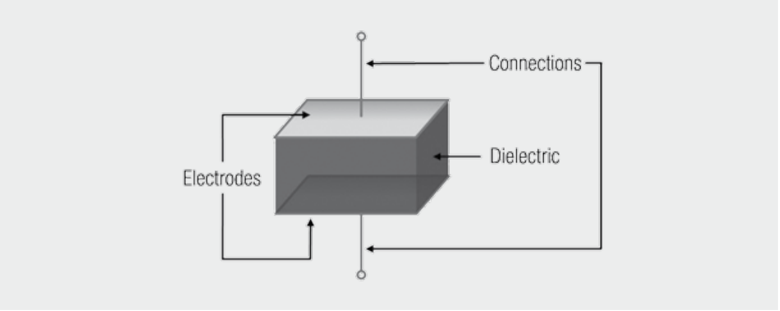

Fig. 1.6: Principle construction of a capacitor

Plate capacitor

The most commonly used arrangement as a technology is the plate capacitor. The principle structure of a plate capacitor consists of two metal plates or foils and a dielectric in the space between them. A plate capacitor and its essential parameters are presented in the following Figure 1.7:

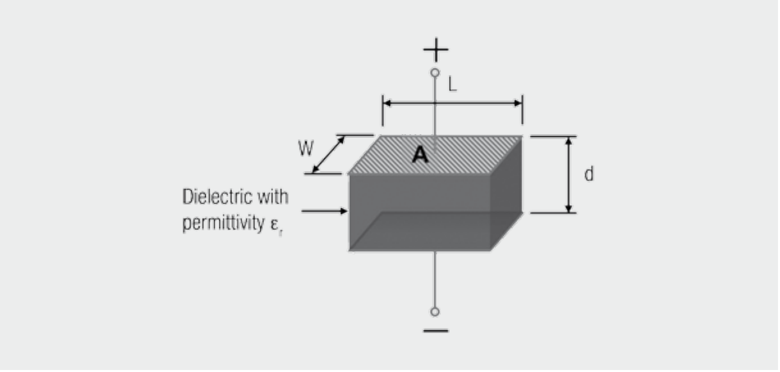

Fig. 1.7: Principle representation of a plate capacitor

Capacitance C

The capacitance C of a capacitor describes its capacity to store electric charges (capacitance is described in more detail in Chapter 2.1 Capacitance of a capacitor). In the case of a plate capacitor, as represented above, its capacitance C can be determined with the following equation:

$$C = \varepsilon * \frac{A}{d} = \varepsilon_0 * \varepsilon_r * \frac{A}{d} \qquad (1.11)$$

The area *A* is determined from the length *L* and width *W* of the electrodes:

$$A = L * W \tag{1.12}$$

The capacitance *C* is calculated from the field constant ε_0, the relative permittivity ε_r of the dielectric used, the effective area *A* (the overlapping area of the electrodes) and the thickness *d* of the dielectric or the separation produced between the electrodes.

The field pattern within an ideal plate capacitor is homogeneous, so that the electric field prevailing in the plate capacitor is of the same magnitude at every point of the field and is uniform throughout. The capacitor types used in modern electronics largely correspond with the principle structure of a plate capacitor.

A capacitor, as an electronic component, is able to store electrical energy and to release it again. The energy release takes place at a defined rate over a certain period depending on its design characteristics.

A capacitor is an energy reservoir, which blocks the direct flow of current with DC voltage and allows the flow of current with AC or pulsating voltage depending on its capacitance and the given frequency. So the capacitor can assume a different role depending on the circuit:

- in a DC circuit it is a charge storage device
- in an AC circuit it is a frequency-dependent resistor

Energy

How much energy a capacitor has stored can be determined from the following formula:

$$E = \frac{C * V^2}{2} = \frac{C * U^2}{2} \tag{1.13}$$

On account of its above properties, the capacitor is an indispensable component in today's electronics. Approximately two-thirds of the passive component market volume is attributable to capacitors. The market for capacitors in relation to sales encompassed a total volume of approximately 13 bn. € in 2012.

Capacitor types

There are various types and constructions of capacitors. Capacitors with fixed capacitance predominate in modern electronics. The main capacitor types of these are presented in the following overview:

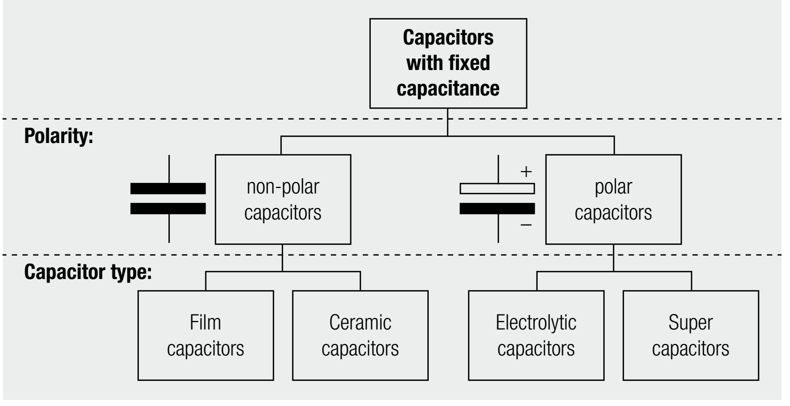

Fig. 1.8: General overview of today's most significant capacitor types with fixed capacitance

Besides the above capacitors with fixed capacitance, there are also capacitors with variable capacitance. Typical examples are rotary or trim capacitors. They play a rather subordinate role in modern electronics as compared with the above capacitors.

The critical distinction is between non-polar and polar variants of capacitors with fixed capacitance. A non-polar capacitor can be operated with DC and AC voltage and it is irrelevant how it is polarized, as the capacitor's electrodes are the same type or are constructed symmetrically.

However, only a DC voltage may be applied to a polar capacitor whose polarity does not change. The electrodes are distinguished as anode and cathode for these designs. The anode has to be connected to the positive and the cathode to the negative potential. The anode and cathode are not the same types for this design. If the polar capacitor is connected incorrectly, damage is caused or there is total failure of the capacitor.

The future development of capacitors includes two essential approaches. On the one hand, the aim is to advance miniaturization in order to keep up with increasing integration density in the electronics industry. On the other hand, the clear focus lies in increasing capacitance, as the capacitor, like the classical rechargeable battery, is a potential energy storage device and with increasing capacitance and advancement it is becoming increasingly attractive.

The important characteristics and parameters of a capacitor are presented and explained in Chapter 2. Subsequently, the various capacitor types are considered in detail in Chapter 3.