## 2 PHYSICAL CHARACTERISTICS

When a voltage is applied to an object such as an electrical conductor, the conductor becomes charged and forces start to act on other charges in the vicinity. Two types of forces may be distinguished: that which arises from stationary electric charges, known as the electrostatic force, and that which appears only when charges are moving (as in an electric current in a conductor), known as the magnetic force. The concept of field has been created to describe the existence and spatial distribution of these forces. Reference is then made to field of force, or simply electric and magnetic fields.

The term static refers to a situation where all charges are fixed in space, or move as a steady flow, so that both charges and current densities are constant in time. For fixed charges there is an electric field whose strength at any point in space depends on the value and geometry of all the charges. For a steady current in a circuit, both the electric and magnetic field are constant in time (static fields), since the charge density at any point of the circuit is constant.

Static electric and magnetic fields are characterized by steady, time independent strengths and correspond to the zero-frequency limit of the extremely low frequency (ELF) band. Electricity and magnetism are distinct phenomena as long as charges and current are static (ICNIRP, 1996).

### 2.1 Quantities and Units

A magnetic field refers to the fields of force, produced by moving electric charges (electric currents), that act on other moving charges. The field from a 'permanent' magnet results from the subatomic spin of electrons. A magnetic field is a vector field, and the fundamental vector quantities describing the magnetic field are the field strength ($H$) and the magnetic flux density ($B$) (or equivalently, the magnetic induction). The magnetic flux density is related to the magnetic field strength by the formula $H=B/\mu$. The value of $\mu$ (the magnetic permeability) is determined by the properties of the medium. In biological material, the magnetic permeability is equal to $\mu_0$, the value of the permeability of free space (air). Thus, the values of $B$ and $H$ for biological materials are related by this constant.

An electric field refers to a region near an electric charge in which a force is exerted on a charged particle. The force between two point charges is described by Coulomb's law. The electric field is denoted by $E$ and is a vector quantity. The SI unit for $E$ is newton per coulomb (N $C^{-1}$). However it is easier to measure the electric potential, $V$, rather than the force and charge, and the unit of volt per metre (V $m^{-1}$) is used in practice. As electric fields exert forces on charged particles, this will cause an electric current to flow in an electrically conductive material. This current is specified by the current density, *J*, with a unit of ampere per square metre (A $m^{-2}$).

The quantities, units, and symbols used in describing electric and magnetic fields are provided in Table 2.

**Table 2. Electric and magnetic field quantities and units in the SI system**

| Quantity | Symbol | Unit |
|---|---|---|
| Electric field strength | $E$ | volt per metre (V $m^{-1}$) |
| Electric flux density | $D$ | Coulomb per square metre (C $m^{-2}$) |
| Current | $I$ | ampere (A) |
| Current density | $J$ | ampere per square metre (A $m^{-2}$) |
| Magnetic field strength | $H$ | ampere per metre (A $m^{-1}$) |
| Magnetic flux | $\varphi$ | weber (Wb) = V s |
| Magnetic flux density | $B$ | tesla[a] (T) = Wb $m^{-2}$ |
| Permeability | $\mu$ | henry per metre (H $m^{-1}$) |
| Permeability of vacuum | $\mu_o$ | $\mu_o = 1.257 \times 10^{-6}$ H $m^{-1}$ |

[a] 1 T = $10^4$ gauss (G), a unit in the CGS unit system