**Lecture-17 AC Circuit – I**

1. **Impedance （阻抗）and admittance （导纳） (lumped element 集总元件)**
* **Resistance -**

 with or

* **Capacitance -**

 🡪

🡪

🡪

* **Inductance –**

Inside the coil, there’s no -field (🡪0) in metal,

🡪

🡪

Now let’s define **impedance**: with

1. **(electric motive force 电动势)** from non-electrostatic force

Consider a loop, the total force that a charge feels is denoted as

, where is the electric motive force.

Since , if , there must be something beyond electrostatics.

**Case 1: Faraday’s Law**  **(induce ）**

**Case 2: Lorenz force （motion-induce ）**

=

since for static field.

On the other hand, inside metal (no resistance)

**Everything is consistent!**

**Case 3: Chemical battery**

=

=

**Inside battery:**  friction

🡪

**(effect of internal resistance)**

Since ,

Here is a constant. Then can be view as internal resistance .

 🡪

1. **Kirchhoff’s rule**
2. **Kirchhoff loop condition**: Consider a loop consisting of a generator and a few lumped elements. We assume no magnetic leaking outside the elements.

The integration path is along the dashed lines. 🡪

Check the loop generator dashed lines

If neglecting internal resistance of the generator:

1. **Kirchhoff node condition:** For each node, the total current sum should be zero.

, pay attention to the positive position.

**\*\*\*Example:**

****Consider the left loop: 🡪

Right loop:

🡪

Node condition:

🡪

🡪

**Generally speaking, Kirchhoff Law applies when the wave feature of is not prominent.** i.e. if the wave length , where is the circuit size.

For ,

 ,

, radio frequency

,

, visible light

\*\*\* In addition, we use the approximation of lumped circuit. We have neglected that circuit itself may carry inductance and capacitance, which we call distributed impedance.

**Condition for Kirchhoff’s Rule**

1. Consider the scale of the entire circuit:

Estimate the contribution from RHS, which is with the period.

The RHS can be neglected if , where is a typical voltage drop across an element. Plug in :

🡪 🡪

Here quantum resistance.

 fine-structure constant. – SI

🡪

② The charge accumulation on a node is at the order of , which cannot exceed the order of with the effective capacitance of the entire circuit.

Since = 🡪

 is negligible, if , where is a typical current.

It means

Since and define

🡪 Kirchhoff’s Law is applicable under the condition:

**Example:**

**\*\*\*For a daily life circuit** (), ,

We have , there should be no problem.

**\*\*\***But if consider a **power system** at , even that , but the typical resistance/impedance: this is an importance constraint.

**\*\*\* For a typical FM radio frequenc**y **circuit** ,

A typical radio size 🡪 .

The application of Kirchhoff’s Law requires