

## SP1

### 旋转交流电机 (Rotating AC Machines)

#### 1. 感应电机 (Induction Motors) :

**工作原理:** 感应电机利用旋转磁场与定子绕组中感应电流之间的相互作用来产生转矩。当交流电流通过定子绕组时, 产生旋转磁场, 该磁场切割转子导体, 产生感应电流, 进而产生电磁转矩。

**滑差 (Slip) :** 滑差是指转子转速与旋转磁场同步速度之间的差值, 是感应电机特性的重要参数。滑差与转矩、电机效率和功率因数密切相关。

**转矩-速度特性 (Torque-Speed Characteristics) :** 理解感应电机的转矩-速度曲线, 包括启动转矩、最大转矩和稳定运行点。

**效率和功率因数:** 分析感应电机的效率和功率因数, 并了解如何通过设计和操作来提高它们。

#### 2. 同步电机 (Synchronous Motors) :

**构造和工作原理:** 同步电机的转子上有永磁体或通过直流电激磁的绕组。当定子绕组通交流电时, 产生旋转磁场, 转子会被锁定在该磁场中, 以同步速度旋转。

**V 曲线:** 理解同步电机在不同励磁条件下的功率因数变化, 以及如何通过调整励磁电流来控制功率因数。

**稳态运行特性:** 学习同步电机在稳态条件下的转矩、速度和电流关系。

#### 3. 异步和同步电机的比较:

**优缺点:** 感应电机以其结构简单、耐用性好、维护成本低著称, 而同步电机可以提供恒定的运行速度和调节功率因数的能力。

**应用场景:** 理解两种电机在不同应用中的优势, 例如感应电机广泛用于工业驱动系统, 而同步电机适用于需要恒速或功率因数控制的场合, 如大型压缩机和发电机组。

Induction Motors:

**Working Principle:** Induction motors operate on the principle of electromagnetic induction. When an AC current passes through the stator windings, it creates a rotating magnetic field that induces a current in the rotor conductors, producing electromagnetic torque.

**Slip:** Slip is the difference between the rotor speed and the synchronous speed of the rotating magnetic field. It is a crucial parameter in the operation of induction motors, affecting torque, efficiency, and power factor.

**Torque-Speed Characteristics:** Understanding the torque-speed curve of induction motors, including the starting torque, maximum torque, and the stable operating point.

**Efficiency and Power Factor:** Analyzing the efficiency and power factor of induction motors and understanding how to improve them through design and operation.

Synchronous Motors:

**Construction and Working Principle:** Synchronous motors have a rotor with permanent magnets or DC-excited windings. The rotating magnetic field generated by the AC current in the stator windings causes the rotor to lock in and rotate at synchronous speed.

**V-Curve:** Understanding the variation of the power factor with different excitation conditions in synchronous motors and how to control the power factor by adjusting the excitation current.

**Steady-State Operating Characteristics:** Learning about the torque, speed, and current relationships of synchronous motors under steady-state conditions.

Comparison between Induction and Synchronous Motors:

**Advantages and Disadvantages:** Induction motors are known for their simple construction, durability, and low maintenance, while synchronous motors offer constant speed operation and power factor control capabilities.

**Applications:** Understanding the advantages of each motor type in different applications, such as induction motors being widely used in industrial drives, while synchronous motors are suitable for applications requiring constant speed or power factor control, like large compressors and generator sets.

## **旋转直流电机 (Rotating DC Machines) :**

### **1.直流电机的类型 (Types of DC Machines) :**

他励电机 (Separately Excited Motors) : 这些电机具有独立的励磁绕组电源, 允许精确控制电机的速度和转矩特性。

并励电机 (Shunt-Wound Motors) : 在并励电机中, 励磁绕组与电枢并联。这些电机在不同负载条件下提供近乎恒定的速度。

串励电机 (Series-Wound Motors) : 励磁绕组与电枢串联。串励电机提供高启动转矩, 适用于起重机和电梯等应用。

复励电机 (Compound-Wound Motors) : 这些电机结合了并励和串励绕组的特点, 提供了启动转矩和速度调节之间的平衡。

### **2.工作原理和特性 (Working Principle and Characteristics) :**

电磁转矩产生 (Electromagnetic Torque Production) : 直流电机的工作原理基于洛伦兹力, 即在磁场中的载流导体受到力的作用。电枢和励磁绕组的磁场相互作用产生转矩。

速度控制 (Speed Control) : 通过改变电枢电压、调节励磁电流或两者结合来控制直流电机的速度。这种灵活性使得直流电机适用于需要可变速度控制的应用。

转矩-速度特性 (Torque-Speed Characteristics) : 理解不同类型直流电机的转矩-速度关系对于选择适合特定应用的电机至关重要。

### **3. 直流电机的启动和制动 (Starting and Braking of DC Motors) :**

启动方法 (Starting Methods) : 直流电机需要一种启动方法来限制初始的冲击电流。常见方法包括使用启动电阻器、串联电阻的起动器或电子起动器。

制动技术 (Braking Techniques) : 直流电机的制动可以通过动态制动、再生制动或反接制动实现。每种方法都有其优势, 根据特定的应用需求选择。

### **4.应用 (Applications) :**

直流电机由于其卓越的速度控制和高启动转矩而被用于广泛的应用。常见应用包括电动车、工业驱动、电梯和起重机。

Types of DC Machines:

Separately Excited Motors: These motors have an independent field winding supply, allowing precise control of the motor's speed and torque characteristics.

Shunt-Wound Motors: In shunt-wound motors, the field winding is connected in parallel with the armature. These motors offer a nearly constant speed under varying load conditions.

**Series-Wound Motors:** The field winding is connected in series with the armature. Series-wound motors provide high starting torque and are suitable for applications like cranes and lifts.

**Compound-Wound Motors:** These motors combine features of both shunt and series windings, providing a balance between starting torque and speed regulation.

**Working Principle and Characteristics:**

**Electromagnetic Torque Production:** DC motors operate on the principle of the Lorentz force, where a current-carrying conductor in a magnetic field experiences a force. The interaction of the magnetic fields of the armature and the field winding results in torque production.

**Speed Control:** The speed of a DC motor can be controlled by varying the armature voltage, adjusting the field current, or both. This flexibility makes DC motors suitable for applications requiring variable speed control.

**Torque-Speed Characteristics:** Understanding the torque-speed relationship of different types of DC motors is essential for selecting the right motor for a specific application.

**Starting and Braking of DC Motors:**

**Starting Methods:** DC motors require a starting method to limit the initial inrush current. Common methods include using a starting resistor, a starter with a series resistance, or electronic starters.

**Braking Techniques:** Braking in DC motors can be achieved through dynamic braking, regenerative braking, or plugging. Each method has its advantages and is chosen based on the specific application requirements.

**Applications:**

DC motors are used in a wide range of applications due to their excellent speed control and high starting torque. Common applications include electric vehicles, industrial drives, elevators, and cranes.

Understanding these key concepts of rotating DC machines is crucial for anyone studying or working in the field of electrical engineering, particularly in areas related to motor control and power systems. These concepts provide a foundation for selecting, operating, and maintaining DC motors effectively in various industrial and commercial applications.

## **变压器 (Transformers)**

### **1. 理想和实际变压器的工作原理**

**电磁感应原理 (Electromagnetic Induction Principle) :** 变压器基于法拉第电磁感应定律工作，当交变电流通过变压器的初级绕组时，产生交变磁通，这个磁通通过次级绕组，产生感应电动势 (EMF)。

**励磁电流和损耗 (Excitation Current and Losses) :** 实际变压器中存在铁损和铜损，铁损由磁芯的磁滞和涡流损耗构成，铜损则由绕组的电阻引起。

### **2. 等效电路、调压和效率**

**等效电路 (Equivalent Circuit) :** 变压器的等效电路用于模拟其内阻和反应特性，包括励磁支路和阻抗分支。

**调压 (Voltage Regulation) :** 调压是指在负载变化时保持次级电压的稳定性。变压器的调压性能是衡量其性能的一个重要参数。

效率 (Efficiency) : 变压器效率是输出功率与输入功率的比值。设计和操作的目标是最小化损耗，以提高效率。

### 3. 三相变压器 (Three-Phase Transformers) :

构造 (Construction) : 三相变压器可以是三个单相变压器的组合，也可以是一个三相核心上的三组绕组。

接线方式 (Connection Methods) : 常见的接线方式有星形 (Y) 连接和三角形 (Δ) 连接，每种接线方式有其特定的应用和优势。

应用 (Applications) : 三相变压器广泛应用于电力系统的传输和分配，以及大型工业负载。

*变压器作为电力系统的关键组件，在电能的传输和分配中发挥着至关重要的作用。它们有助于优化变压器的设计、操作和维护，确保电力系统的高效和可靠运行。*

Working Principle of Ideal and Practical Transformers:

Electromagnetic Induction Principle: Transformers operate based on Faraday's law of electromagnetic induction. An alternating current passing through the primary winding creates a changing magnetic flux, which induces an electromotive force (EMF) in the secondary winding.

Excitation Current and Losses: Practical transformers experience core (iron) losses and copper losses. Core losses consist of hysteresis and eddy current losses in the magnetic core, while copper losses are due to the resistance of the windings.

Equivalent Circuit, Voltage Regulation, and Efficiency:

Equivalent Circuit: The equivalent circuit of a transformer models its internal resistance and reactance, including the excitation branch and the impedance branch.

Voltage Regulation: Voltage regulation refers to maintaining the stability of the secondary voltage under varying load conditions. It is an important performance parameter for transformers.

Efficiency: Transformer efficiency is the ratio of output power to input power. The goal in design and operation is to minimize losses and improve efficiency.

Three-Phase Transformers:

Construction: Three-phase transformers can be a combination of three single-phase transformers or a single unit with three sets of windings on a three-phase core.

Connection Methods: Common connection methods include star (Y) and delta (Δ) connections, each with specific applications and advantages.

Applications: Three-phase transformers are widely used in the transmission and distribution of electrical power systems and for large industrial loads.

## Switching Circuits(开关电路):

### 1. 半导体开关 (Semiconductor Switches) :

晶体管 (Transistors) : 包括双极型晶体管 (BJTs) 和场效应晶体管 (FETs)，是电子电路中基本的开关元件。它们用于控制电流的流动，并能快速切换状态。

晶闸管 (Thyristors) : 如硅控整流器 (SCRs)，用于更高功率的应用。它们能够处理大电流和高电压，常用于电力控制和转换应用。

MOSFETs: 金属-氧化物-半导体场效应晶体管 (MOSFETs) 因其高速切换和高效率而广

泛使用。适用于低功率和高功率应用。

## 2. 电力电子变换器 (Power Electronic Converters) :

**整流器 (Rectifiers) :** 将交流 (AC) 转换为直流 (DC)。用于电源、电池充电和直流电机驱动。整流器可以是可控的 (使用 SCRs) 或不可控的 (使用二极管)。

**逆变器 (Inverters) :** 将直流 (DC) 转换为交流 (AC), 在太阳能系统、不间断电源 (UPS) 和交流电机的变频驱动中至关重要。

**斩波器 (Choppers, DC-DC Converters) :** 用于控制直流电路的电压。应用于电动车和直流电机速度控制等。

**交流-交流变换器 (AC-AC Converters) :** 修改交流电源的幅度和/或频率, 用于需要变速交流驱动的应用。

## 3. 保护电路 (Protection Circuits) :

**过流保护 (Overcurrent Protection) :** 防止过大的电流损坏元件。常见方法包括熔断器、断路器和限流电阻。

**过压保护 (Overvoltage Protection) :** 防止可能导致绝缘击穿的电压尖峰。技术包括使用压敏电阻器、齐纳二极管和瞬态电压抑制器。

## 4. 应用 (Applications) :

开关电路在从电源、电机控制到复杂的电力电子系统的多种应用中都是不可或缺的。它们在工业和消费电子中使电能的控制和转换更加高效。

理解这些开关电路的关键概念对于在电气和电子工程领域学习或工作的人来说至关重要。这些概念为设计、分析和排除电力电子和控制系统应用中的电路故障提供了基础。

### 1. Semiconductor Switches:

Transistors: Transistors, including Bipolar Junction Transistors (BJTs) and Field-Effect Transistors (FETs), are fundamental switching elements in electronic circuits. They are used to control the flow of current and can switch between states rapidly.

Thyristors: Thyristors, such as Silicon-Controlled Rectifiers (SCRs), are used in higher power applications. They are capable of handling large currents and voltages and are often used in power control and conversion applications.

MOSFETs: Metal-Oxide-Semiconductor Field-Effect Transistors (MOSFETs) are widely used due to their high switching speed and efficiency. They are suitable for both low and high power applications.

### 2. Power Electronic Converters:

Rectifiers: Rectifiers convert AC to DC. They are used in power supplies, battery charging, and DC motor drives. Rectifiers can be controlled (using SCRs) or uncontrolled (using diodes).

Inverters: Inverters convert DC to AC and are essential in applications like solar power systems, UPS (Uninterruptible Power Supplies), and variable frequency drives for AC motors.

Choppers (DC-DC Converters): Choppers are used to control the voltage of DC circuits. They are used in applications like electric vehicles and DC motor speed control.

AC-AC Converters: These converters modify the amplitude and/or frequency of the AC supply and are used in applications requiring variable speed AC drives.

### 3. Protection Circuits:

Overcurrent Protection: Protects against excessive current that could damage

components. Common methods include fuses, circuit breakers, and current-limiting resistors.

Overvoltage Protection: Protects against voltage spikes that could cause insulation breakdown. Techniques include the use of varistors, Zener diodes, and transient voltage suppressors.

#### 4.Applications:

Switching circuits are integral in a variety of applications ranging from power supplies, motor controls, to complex power electronic systems. They enable efficient control and conversion of electrical energy in both industrial and consumer electronics.