

21.2 Rectification and smoothing

Name: _____ Class: _____ Date: _____

Total: 27 marks

KEY WORDS rectification 整流 • bridge rectifier 桥式整流器 • diode 二极管 • smoothing 平滑
• half-wave rectification 半波整流

Objective

Build the skills to answer exam questions on **rectification** and **smoothing**.

You must be able to:

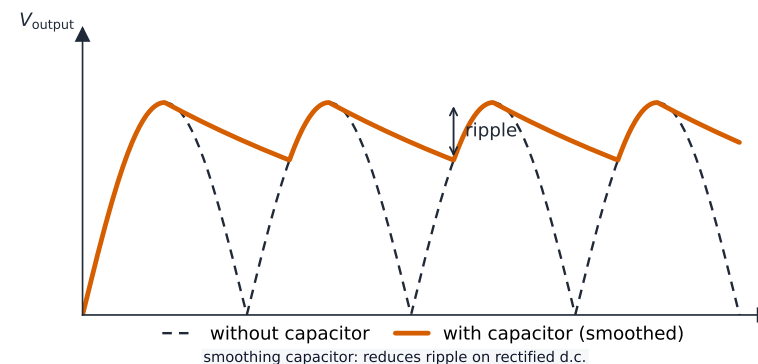
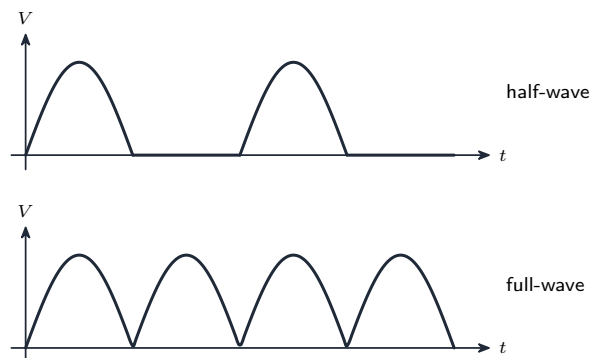
- distinguish **half-wave** and **full-wave** rectification
- explain the **single diode** and the **bridge rectifier**
- explain capacitor **smoothing**

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Rectification

Rectification turns a.c. into one-direction (d.c.-like) voltage using **diodes**:



A smoothing capacitor after rectification

- **half-wave** (single diode): passes only positive half-cycles — half the input wasted;
- **full-wave** (4-diode **bridge rectifier**): uses every half-cycle, giving continuous humps at **twice** the frequency.

■ Smoothing

A **capacitor** across the load charges on each peak and discharges through the load in the gaps, reducing the **ripple**. A **larger** capacitance (or larger load resistance) gives **smoother** output (larger time constant RC).

2 Practice

Now apply the methods above.

2.1 State what **rectification** does. [1]

2.2 State how many **diodes** a bridge rectifier uses. [1]

2.3 State the difference between **half-wave** and **full-wave** output. [2]

2.4 State the purpose of a **smoothing capacitor**. [1]

3 Exam-style questions

3.1 A **single diode** in series with a load produces: [1]

- **A** full-wave rectification
- **B** half-wave rectification
- **C** smoothed d.c.
- **D** alternating current

3.2 Explain how a single diode produces **half-wave** rectification. [2]

3.3 Describe how a **bridge rectifier** (four diodes) achieves **full-wave** rectification. [3]

3.4 Explain how a **capacitor** smooths the output, and what happens to the smoothing if the **capacitance is increased**. [3]

3.5 A bridge rectifier is built from four diodes and supplied with a sinusoidal input of peak voltage 12 V. The input completes 8 cycles in 2.8 s.

(a) **State** what is meant by **rectification**, and name the type produced by a bridge rectifier. [2]

(b) **Show that** the period of the input is 0.35 s. [1]

(c) **Calculate** the root-mean-square input voltage. [2]

(d) In the space below, **sketch** the output voltage V_{OUT} across the load against time, from $t = 0$ to $t = 0.35$ s. **Label** both axes with values. [3]

(e) A large capacitor is now connected **across the load**. On the same sketch, **draw** the new output and **explain** its shape. [3]

(f) **State and explain** the effect on the smoothed output of (i) using a larger capacitance, and (ii) connecting a smaller load resistance. [2]

Solutions

Each answer shows the steps, then the **result**.

2.1

- turns an **alternating** voltage/current into a **one-direction** (d.c.-like) one

2.2

- **four**

2.3

- half-wave keeps **only the positive half-cycles** (with gaps)
- full-wave **inverts the negative half-cycles** too, giving a continuous run of positive humps at twice the frequency

2.4

- to **smooth** the output — reduce the ripple, giving a steadier d.c.

3.1 B

- a single diode gives **half-wave rectification**

3.2

- the diode conducts only when **forward-biased** (positive half-cycle)
- on the negative half-cycle it is **reverse-biased** and blocks the current, so only positive humps pass

3.3

- four diodes are arranged so that on **each** half-cycle a **different pair** conducts
- whichever a.c. terminal is positive, the current through the load flows the **same way**
- so every half-cycle is used, giving full-wave output

3.4

- the capacitor **charges** to the peak and **discharges** slowly through the load during the dips, filling the gaps and reducing the ripple
- a **larger** capacitance increases the time constant RC
- so it discharges more slowly and the output is **smoother** (smaller ripple)

3.5

(a) rectification is the conversion of **alternating** current into **direct** (one-directional) current

- a bridge rectifier gives **full-wave** rectification

(b) $T = 2.8 \text{ s}/8 = \mathbf{0.35 \text{ s}}$

(c) $V_{\text{r.m.s.}} = V_0/\sqrt{2}$

$$V_{\text{r.m.s.}} = \frac{12 \text{ V}}{\sqrt{2}} = \mathbf{8.5 \text{ V}}$$

(d) all humps **above** the axis — the negative half-cycles are flipped up

- **two** humps in 0.35 s, so the output period is 0.175 s
- peak value 12 V, axes labelled

(e) the output becomes a **smoothed** line that rises with each hump to 12 V and then decays gently until the next hump catches it

- the capacitor **charges** to the peak, then **discharges** through the load while the rectified voltage falls
- so the output never drops to zero and the remaining variation is the **ripple**

(f) (i) a larger capacitance stores more charge and discharges more slowly ($\tau = RC$ is longer), so the ripple is **smaller**

(ii) a smaller load resistance draws more current and shortens τ , so the capacitor discharges further between humps and the ripple is **larger**