Exercise walk-through

Rectification and smoothing ▪ 21.2

eXercise

You must be able to

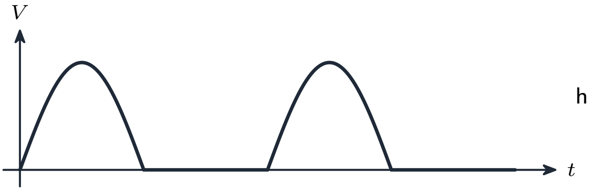
- distinguish **half-wave** and **full-wave** rectification
- explain the **single diode** and the **bridge rectifier**
- explain capacitor **smoothing**

Method — Rectification

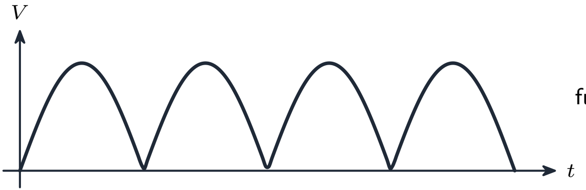
Rectification turns a.c. into one-direction (d.c.-like) voltage using **diodes**:

- **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.

Method — Rectification

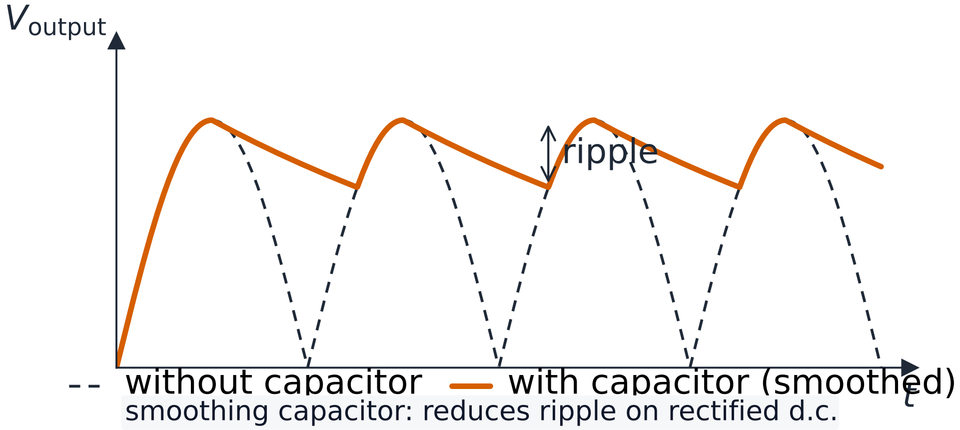


half-wave



full-wave

Method — Rectification



A smoothing capacitor after rectification

Method — 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).

Practice 2.1 ▪ 1 mark

State what **rectification** does.

Solution 2.1

Worked steps

Turns an **alternating** voltage/current into a **one-direction** (d.c.-like) one B1.

Practice 2.2 ▪ 1 mark

State how many **diodes** a bridge rectifier uses.

Solution 2.2

Method: Rectification

Worked steps

Four B1.

Practice 2.3 ▪ 2 marks

State the difference between **half-wave** and **full-wave** output.

Solution 2.3

Method: Rectification

Worked steps

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 **B1** **B1**.

Practice 2.4 ▪ 1 mark

State the purpose of a **smoothing capacitor**.

Solution 2.4

Worked steps

To **smooth** the output — reduce the ripple, giving a steadier d.c. **B1**.

Exam-style 3.1 ▪ 1 mark

A **single diode** in series with a load produces:

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

Solution 3.1

Method: Rectification

A full-wave rectification

B half-wave rectification ✓

C smoothed d.c.

D alternating current

Worked steps

B — half-wave rectification.

Exam-style 3.2 ▪ 2 marks

Explain how a single diode produces **half-wave** rectification.

Solution 3.2

Method: Rectification

Worked steps

The diode conducts only when **forward-biased** (positive half-cycle) B1; on the negative half-cycle it is **reverse-biased** and blocks the current, so only positive humps pass B1.

Exam-style 3.3 ▪ 3 marks

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

Solution 3.3

Method: Rectification

Worked steps

Four diodes are arranged so that on **each** half-cycle a **different pair** conducts **B1**; whichever a.c. terminal is positive, the current through the load flows the **same way** **B1**; so every half-cycle is used, giving full-wave output **B1**.

Exam-style 3.4 ▪ 3 marks

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

Solution 3.4

Method: Smoothing

Worked steps

The capacitor **charges** to the peak and **discharges** slowly through the load during the dips, filling the gaps and reducing the ripple **B1**; a **larger** capacitance increases the time constant RC **B1**, so it discharges more slowly and the output is **smoother** (smaller ripple) **B1**.

Exam-style 3.5 ▪ 2 marks

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.
(b) **Show that** the period of the input is 0.35 s.
(c) **Calculate** the root-mean-square input voltage.
(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.
(e) A large capacitor is now connected **across the load**. On the same sketch, **draw** the new output and **explain** its shape.
(f) **State and explain** the effect on the smoothed output of (i) using a larger capacitance, and (ii) connecting a smaller load resistance.

Solution 3.5

Worked steps

(a) Rectification is the conversion of **alternating** current into **direct** (one-directional) current **B1**; a bridge rectifier gives **full-wave** rectification **B1**.

(b) $T = \dfrac{2.8}{8} = 0.35$ s **A1**.

(c) $V_{\text{r.m.s.}} = \dfrac{V_0}{\sqrt{2}} = \dfrac{12}{\sqrt{2}}$ **M1** $= 8.5$ V **A1**.

(d) All humps **above** the axis — the negative half-cycles are flipped up **B1**; **two** humps in 0.35 s, so the output period is 0.175 s **B1**; peak value 12 V, axes labelled **B1**.

(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 **B1**. The capacitor **charges** to the peak, then **discharges** through the load while the rectified voltage falls **B1**, so the output

Solution 3.5

Worked steps

never drops to zero and the remaining variation is the **ripple** B1.
(f) (i) A larger capacitance stores more charge and discharges more slowly ($\tau = RC$ is longer), so the ripple is **smaller** B1. (ii) A smaller load resistance draws more current and shortens τ, so the capacitor discharges further between humps and the ripple is **larger** B1.