

# ELECTRONICS

## 1. Rectification and smoothing of a.c.

### a. half-wave rectification

The circuit consists of a rectifier in series with the a.c. input to be rectified and the “load” ( $R$ ) requiring the d.c. output. The diode allows current to pass only in one direction, so the p.d. output and input obey the graph below. This means that just half the energy “offered” by the source is really used.

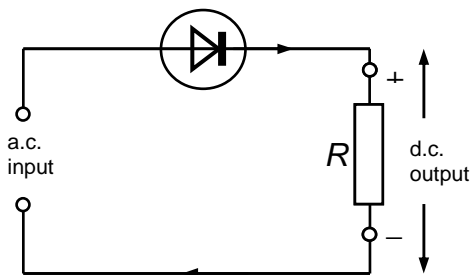
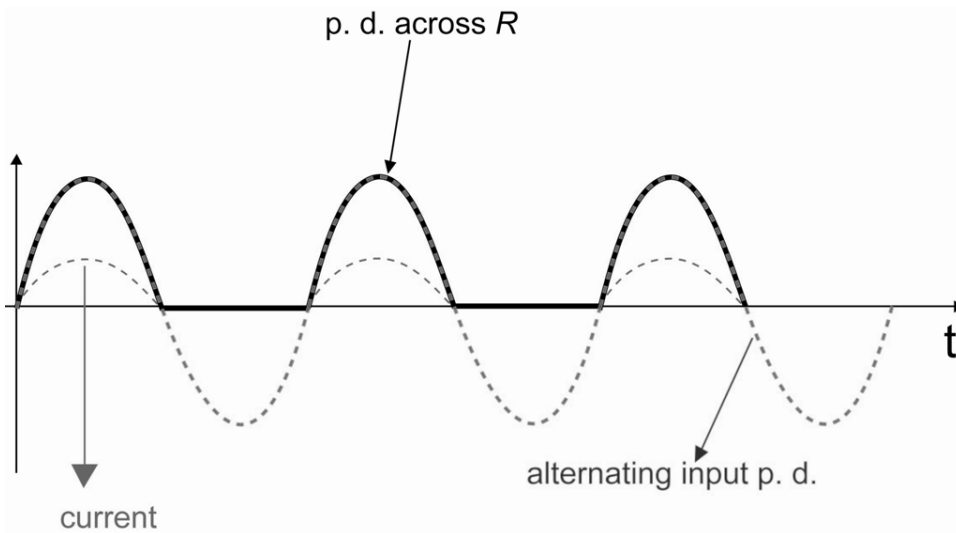


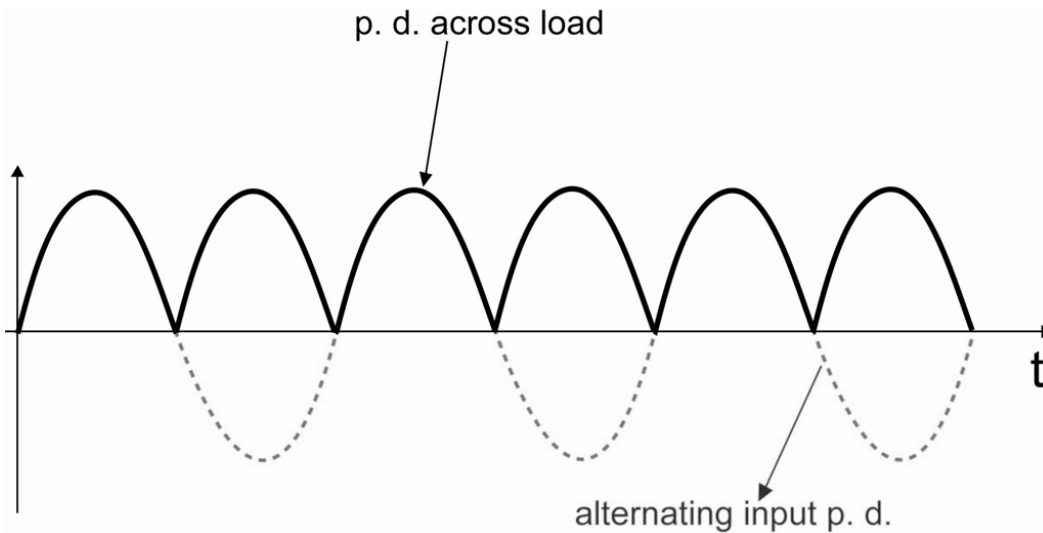
Figure 1



### b. full-wave rectification

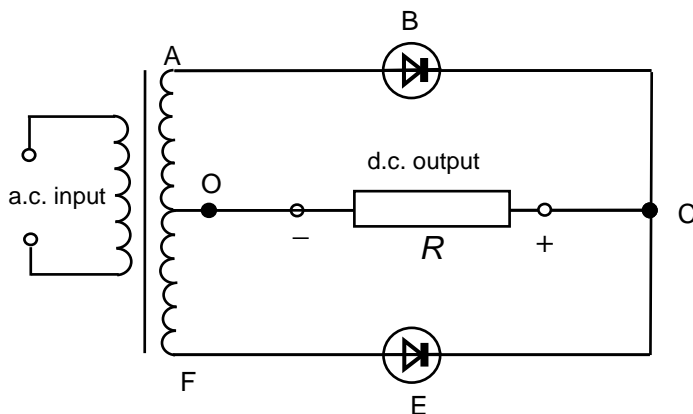
In this situation the energy is used in both halves of the period. The input and output vary as shown in the graph.

Figure 2



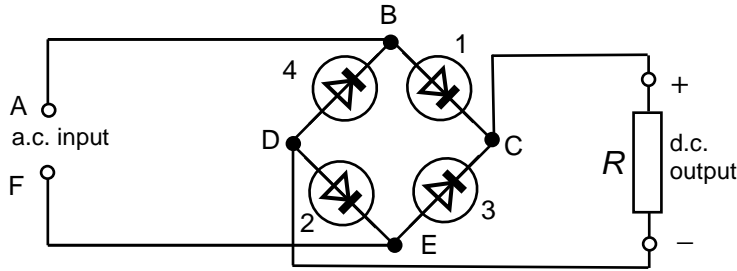
**i) centre-tap full wave rectifier**

Two diodes and a centre-tapped secondary winding are used. If the first half-cycle of input makes A positive, diode B conducts. During this half-cycle the other diode E is non-conducting since the p.d across FO reverse biases it. On the other half-period the situation is vice versa so the current through R is in the same direction during BOTH half-cycles and a fluctuating = changing direct p.d is created across it. An advantage could be the separation of primary and secondary circuit (in medicine) or a simple change of voltage (in transformers), disadvantage some energy "lost" (transformers).



**ii) bridge full-wave rectifier**

Four diodes are arranged in a bridge network as shown. If A is positive during the first half-cycle, diodes 1 and 2 conduct. On the next half-cycle diodes 3 and 4 conduct, which gives the p.d. in the same direction across R.



**c. smoothing**

To produce steady d.c. from the varying but unidirectional output from rectifiers, smoothing is necessary. The simplest smoothing circuit consists of a large capacitor ( $16 \mu\text{F}$  or more) placed in parallel with the load R. The rectified input p.d. causes current to flow through R and at the same time  $C_1$  is charged. When the input p.d. falls,  $C_1$  starts to discharge. As the polarity of the input is wrong, it is discharged through the load and thus maintains current flow. To improve the effect a connection of more capacitors and coils (which work "against the change") can be used.

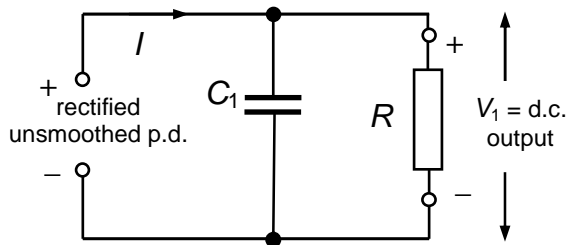
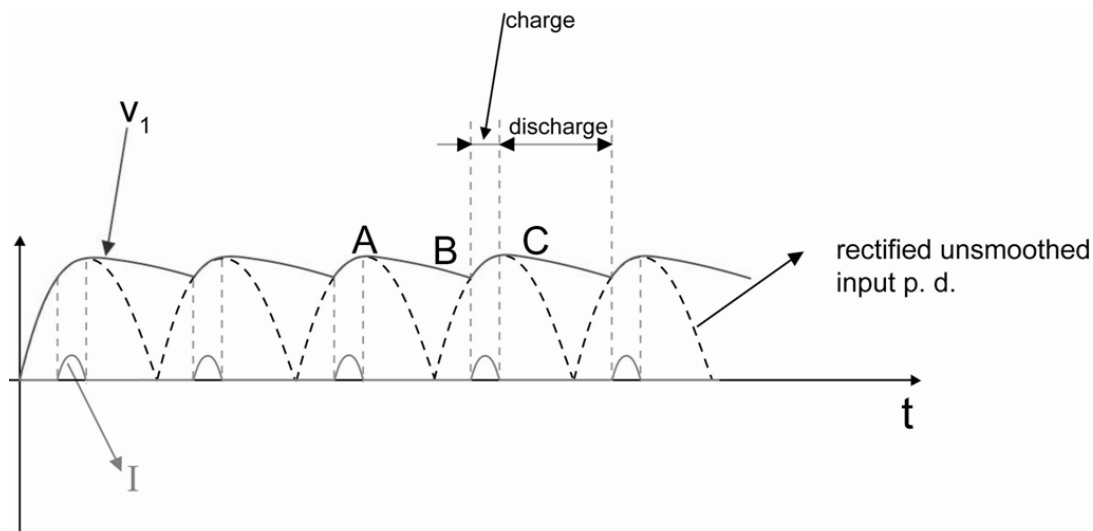
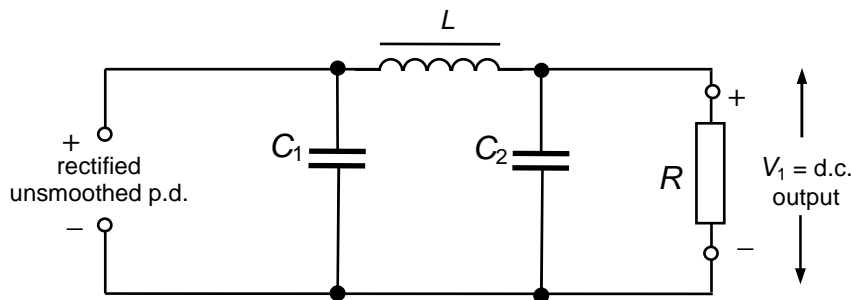


Figure 3



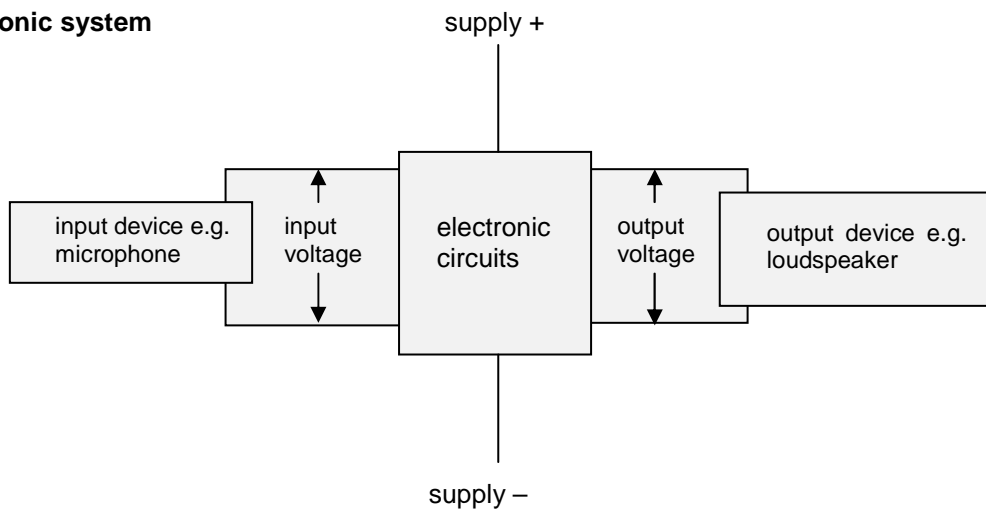


## 2. Transistors

See worksheets ELECTRIC CURRENT IN SEMICONDUCTORS part 4.

## 3. Amplifiers

### Basic electronic system



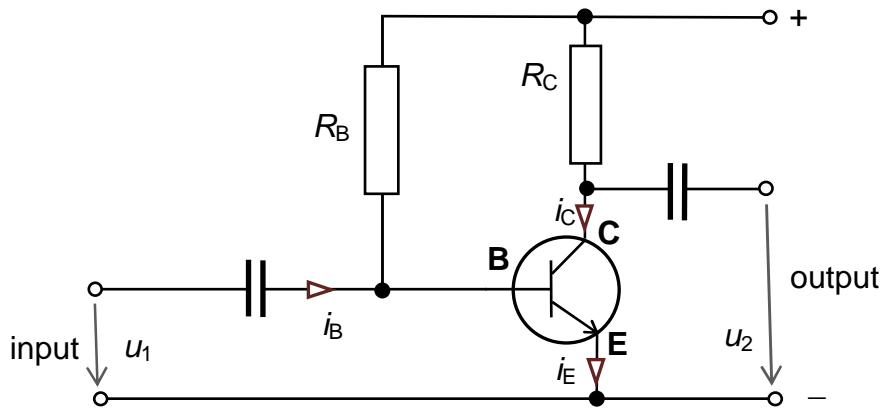
Note:

- Devices which change signals from one form to another (e.g. sound to electrical) are called **transducers**.
- Input signal can be very weak. But by means of el. circuits, they can control output signals which can be much stronger. The output power is provided by the supply.

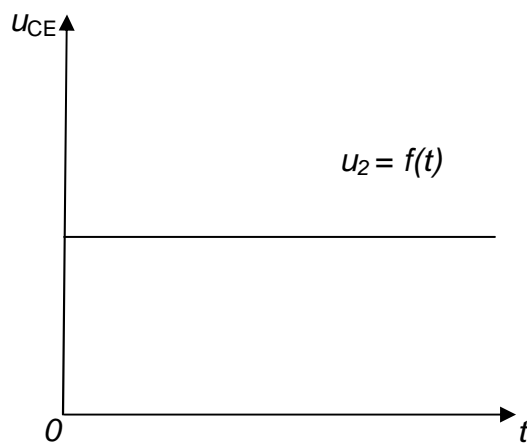
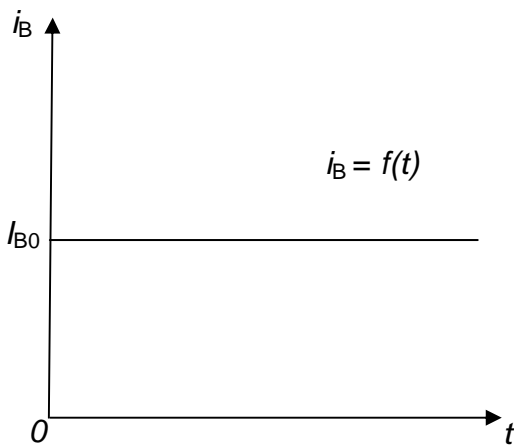
One of the functions of el. circuits is **amplification**. The output signals are magnified versions of the input signals, e.g. very low voltage AC from a microphone causes a higher voltage AC output for a loudspeaker.

$$\frac{\text{output voltage}}{\text{input voltage}} = \text{voltage gain}$$

A junction **transistor** in the common-emitter mode can act as a voltage amplifier if a suitable resistor (load) is connected in the collector circuit.



Finish graphs:



#### 4. Integrated circuits (ICs)

Integrated circuits may contain hundreds of thousands of transistors and often diodes, resistors and small capacitors formed on a tiny chip of silicon, no more than 5 mm square and 0.5 mm thick and connected together by thin aluminium strips.

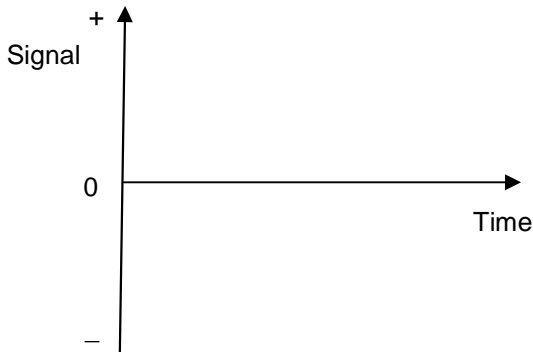
##### a) Analogue ICs (linear)

These include **amplifier-type circuits**. They handle signals that are often el. representations of physical quantities such as sound intensity, which change smoothly and continuously over a range of values between a maximum and a minimum.



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Sketch an example of an analogue signal:

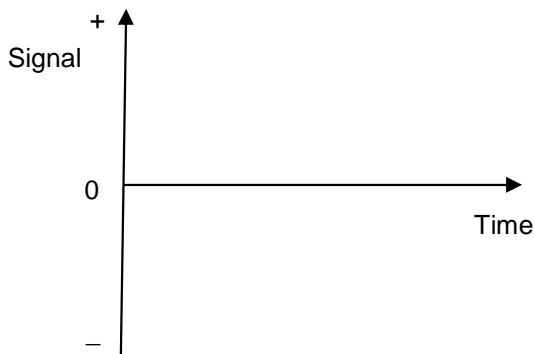


One of the most versatile analogue ICs is the operational amplifier (op amp).

## b) Digital ICs

These contain **switching-type circuits** that process el. signals which have only one of two values.

Sketch an example of a digital signal:



The digital signal consists of a string of pulses, which can be transmitted as **voltage pulses** along a wire or as **light pulses** along an optical fibre.

**Voltage pulses** – their inputs and outputs are either “high” (e.g. near the supply voltage, often 5 V) or “low” (e.g. near 0 V), no other level is allowed. **Logic** is at the core of digital electronics: signals are either low or high like “false” – represented by 0 or “true” – represented by 1.

Digital ICs contain circuits such as logic gates, astables, bistables, adders, counters, memories and microprocessors, which are the subject matter of electronics.

Two main types of digital ICs:

i) *TTL (Transistor-Transistor-Logic)* – using junction transistors

ii) *CMOS (pronounced “see-moss”)* standing for *Complementary Metal Oxide Semiconductor* – based on Field Effect Transistors



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*Note:*

**Analogue-to-digital conversion** refers to the conversion of information in analogue form to information in digital form, a process that must be carried out before data can be manipulated by a digital computer. This process converts the analogue voltage to a number (with, for example, 8 bits) that can be represented by a string of pulses.

If we use an eight-bit number to represent the possible values of the signal, the signal may have any one of  $2^8 = 256$  possible values, from 0000 0000 to 1111 1111.

## **LOGIC GATES**

Information from an enormous variety of sources (sensors, keyboards...) may be encoded in binary form and transmitted as a series of pulses and then processed using el. circuits built up from **logic gates**.

Logic gates are capable of performing operations that **make simple decisions** about an output based on one or more inputs. Examples: NOT gate or inverter, NOR gate, OR gate, AND gate, NAND gate...

**Use:** pocket calculators, systems to monitor and control the performance of cars, microwave ovens, computers, robots, industrial control systems, in telecommunications...

*See additional material (1): LOGIC GATES*