PACEMAKER
Natural pacemaker:
The heart's "natural" pacemaker is called the sinoatrial (SA) node or sinus node.

- Artificial pacemaker:
  It is a small, battery-operated device that helps the heart beat in a regular rhythm. They can replace a defective natural pacemaker or blocked pathway.
Energy required to excite heart muscle

The heart muscles can be stimulated with an electric shock.

- The min energy required to excite the heart muscle is 10µJ. For better simulation a pulse of 100µJ is applied.
- Too high pulse may provoke ventricular fibrillation (ventricles fail to fill).
- The patient looses conscious and die in 10-15 seconds and brain cells die within few minutes from O₂ deficiency at 400µJ pulse.
They have pulse to space ratio 1:10000 and that should be negatively going pulse to avoid ionisation.
- Temporary or External pacemakers
- Internal or permanent pacemakers
Temporary or External pacemakers

- Temporary pacemakers are used in emergency settings or during overdose of medications to restart the normal rhythm of the heart.
- The pacemakers are placed outside the body.
- The electrodes used are called ENDOCARDIAC electrodes.
- The battery can be easily replaced and defects in the circuit can be easily made.
Internal or permanent pacemakers

They are used when the slow heart rate becomes chronic or is believed to be irreversible.

- The electrodes used are called MYCORDIAC electrodes. ENDOCARDIAC electrodes are also used.
- It requires open heart minor surgery to place the circuit.
- The pacemaker is implanted into the chest or abdomen, usually on the left side of the chest.
A dual-lead pacemaker sends a charge to the atrium and ventricle.
• Attached to the generator are one or more leads, or wires, generally made of platinum with an insulating coating of either silicone or polyurethane. The leads carry the electrical impulses from the generator.

• At the tip of each lead is a tiny device called an electrode that delivers the necessary electrical impulses to the heart.

• Thus, the electric impulses are created by the generator, carried by the leads and delivered by the electrodes to the heart.
Different Modes of Operation

- Ventricular asynchronous pacemaker
- Ventricular synchronous pacemaker
- Ventricular inhibited pacemaker
- Atrial synchronous pacemaker
- Atrial sequential ventricular inhibited pacemaker
Ventricular asynchronous pacemaker

Square-wave generator

Monostable multivibrator

Fig. 5.2. Ventricular asynchronous pacemaker
Ventricular asynchronous pacemaker

- The pacemaker can be used in atrium or ventricle.
- It uses a simple astable multivibrator.
- There may be competition between normal heart beat and pacemaker beats, this is dangerous.
- First blocking oscillator with transformer were used then transistorized blocking oscillator with a pulse amplifier were used.
- But now a days fixed rate pacemaker is fabricated on a single large scale integrated circuit.
It consists of a square wave generator and a positive edge triggered monostable multivibrator.

\[ T = -2RC \ln\left(\frac{1-\alpha}{1+\alpha}\right) \]

Where \( \alpha \) is the feedback voltage such that \( \alpha = \frac{R_2}{R_1+R_2} \) according to the figure pulse with period \( T = 0.8589 \text{ secs} \).

Pulse duration \( T_D = \frac{(R_3R_4)}{(R_3+R_4)} \times 5C \)

\( T_D = 0.437 \text{ m secs} \)
DISADVANTAGES:

• Here the heart rate cannot be increased to match greater physical effort.

• This varies stroke volume of the heart which cause some loss in cardiac output.
They are preferred for short periods of AV block.

- Using sensing electrode heart rate is detected & is given to timing circuit of pacemaker.
- If the heart rate is below a min rate then pacemaker is turned on.
The lead used to detect the R wave is now used to stimulate the heart.

If natural contraction occurs then asynchronous pacer's timing circuit is reset so that it will tie its next pulse to detect the heart beat else produce pulse at its present rate.

ADVANTAGES:
- To arrest the ventricular fibrillation, this circuit can be used.
- Power consumption is reduced.

DISADVANTAGES:
- Atrial and ventricular contraction are not synchronized.
- The circuit is more sensitive to eternal electromagnetic interference.
Fig. 5.4. Ventricular inhibited pacemaker
Ventricular inhibited or demand pacemaker

This pacemaker also allows the heart to pace at its normal rhythm when it is able to.

- Only if the heart beat falls to min rate the pacemaker turns on and hence called as DEMAND pacemaker.
- The timing circuit consists of an RC network a reference voltage source and a comparator which detects the basic rate of the pulse generator.
- The output of the timing circuit is fed into the RC network.
- The pulse width determines the duration of the pulse delivered to the heart. The output circuit provides proper pulse to stimulate the heart.
Atrial synchronous pacemaker

Fig. 5.5. Block diagram for atrial synchronous pacemaker
Atrial synchronous pacemaker

It is used for young patients with mostly a stable block.

- Used to terminate arterial flutter and paroxymal atrial tachycardia and act as temporary pacemaker for atrial fibrillation.
- The atria activity is picked up by a sensing electrode.
- The detected P wave is amplified and a delay of 0.12sec is provided by the AV delay circuit.
- This signal is used to trigger resetable multivibrator & the output is given to the amplifier which produces the stimulus to the heart.
Atrial sequential ventricular inhibited pacemaker

- It has the capability of stimulating both the atria and ventricle and adopts its method of stimulation to patient’s needs.
- If atrial fails this pacemaker will stimulate the atrium and the sense the ventricular beat.
- A magnet is placed over the pacemaker on the skin of the patient order to activate a reed switch, which switches the pacemaker to any modes.