

# *Physics of Ultrasound*

*Eight lecture*

## *Transducers for Real-Time Imaging*

*Dr. Nasma Adnan*

*Third Stage*

*Department of medical physics*

*Al-Mustaqbal University-College*

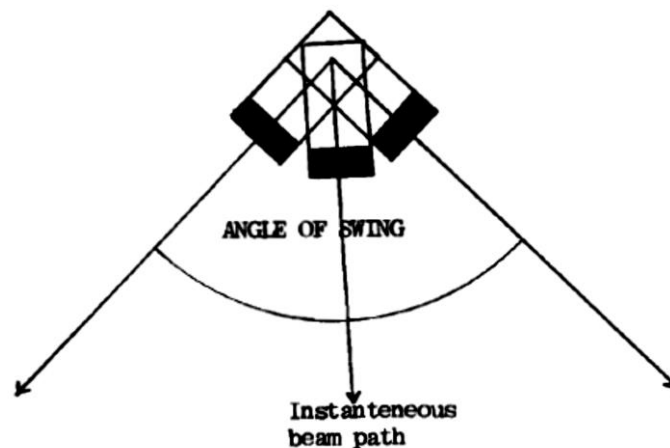
*2021- 2022*

## 1. Transducer design

- Transducers for real-time imaging may be classified broadly into two categories:
- mechanical transducers and electronic transducers.
- mechanical transducers, the beam sweep is achieved through physical movement of some part of the transducer, usually the crystal element(s).
- electronic transducers the beam is swept by electronic activation of crystal elements, without causing the transducer to move physically.

## 2. Mechanical transducers

- ✚ Mechanical transducers are made using either a single piezoelectric crystal or a small group of crystals.
- ✚ A single crystal element may be rocked to perform pendulum motion through a suitable angle.
- ✚ The motion is effected using an electric motor. The angle of swing will define the field of view.
- ✚ The image is triangular in shape and is referred to as a sector scan.
- ✚ Each swing of the crystal produces one image frame, and the frame rate is equal to the number of swings per second.



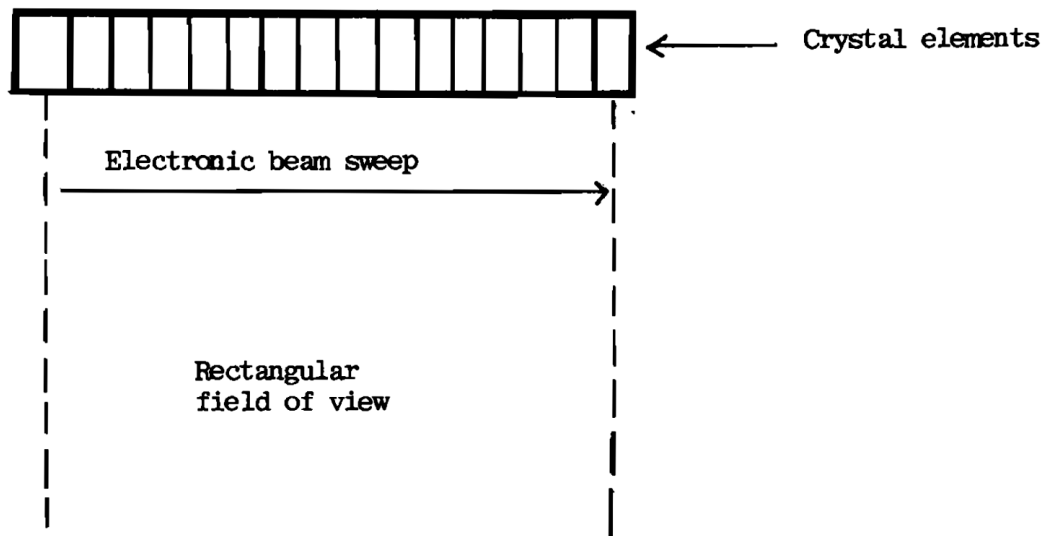
### 3. Electronic transducers

- ✚ Electronic transducers are made from a large number of small, identical crystal elements which are acoustically insulated from each other.
- ✚ The crystals are arranged in a suitable geometrical configuration, or an **array**, to provide the desired field of view.
- ✚ Movement of the beam is effected by exciting the crystal elements in an orderly fashion without having to move the transducer physically.
- ✚ The crystal elements may be pulsed individually, one at a time, to provide the instantaneous beam, a pulsing procedure known as **sequential pulsing**.
- ✚ Alternatively, the instantaneous beam may be provided by a small group of crystals excited together. The group is a segment of the array, and such group pulsing is called **segmental pulsing**.
- ✚ The choice between sequential and segmental pulsing is dictated by the need to provide a suitable beam shape that optimizes the conflicting interests of a narrow beam to enhance spatial resolution, on the one hand, and a sufficiently long Fresnel zone that allows for adequate tissue depths to be investigated, on the other hand.
- ✚ **In** a multi-crystal transducer with very many crystal elements, the crystals will, of necessity, be small in size, otherwise the transducer would be too large and bulky. It will be recalled that a small source of ultrasound produces an unsatisfactory beam shape, a short Fresnel zone and rapid divergence in the far field.

#### Geometry of multi crystal arrays

Different geometrical configurations have been used in multi crystal arrays. In **linear array transducers**, the crystal elements are arranged in a row. They may be activated either sequentially or segmental. They

generate rectangular fields of view associated with good visualization of superficial regions.



In an **annular array transducer**, the crystal elements are arranged in concentric rings. For electronic beam sweep, the set of typically 5 - 10 ring elements is pulsed sequentially to move the beam from the innermost ring outwards. The beam can also be moved mechanically by oscillating the whole assembly from side to side, or by reflecting the beam from a moving acoustic mirror.

A **phased array** system may have the same geometrical configuration as either a linear array or an annular array, but the procedure of activating the crystal elements is different. Neither sequential nor segmental pulsing is employed. In phased array transducers, all the crystal elements are pulsed almost instantaneously as one group, excepting for very short time delays between the activations of individual crystal elements. The carefully controlled electronic time delays are programmed into the pulsing of each crystal element to facilitate movement and focusing of the beam