Al-Mustaqbal University

Biomedical Engineering Department

Class: 5th

Subject: Biomedical Instrumentation Lab

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1st term – Lect. 3: Ultrasound machine

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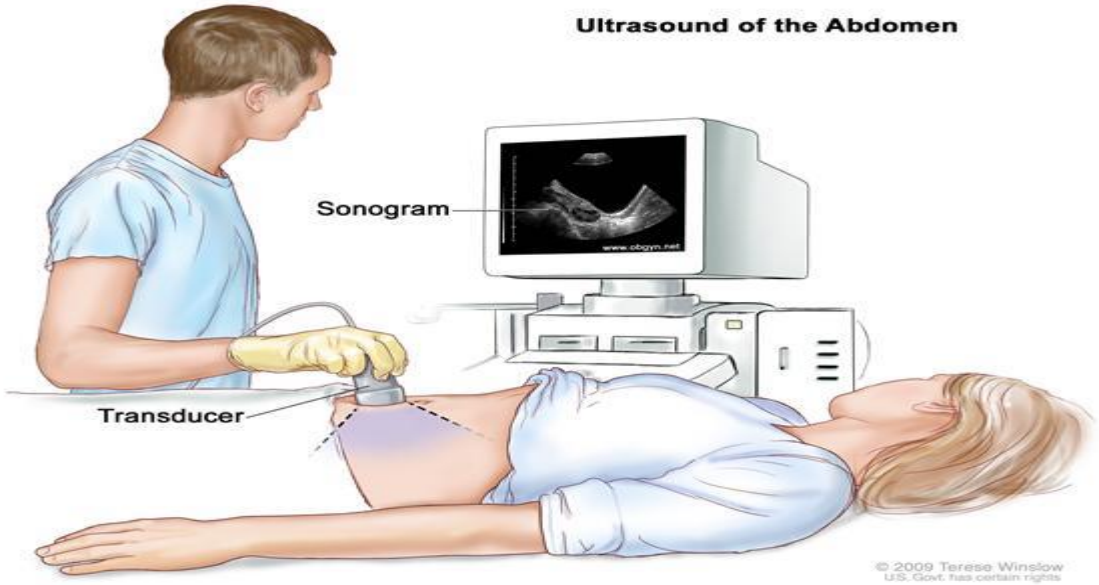
Ultrasound machine

An ultrasound is an imaging test that uses sound waves to make pictures of organs, tissues, and other structures inside your body. It allows your health care provider to see into your body without surgery.

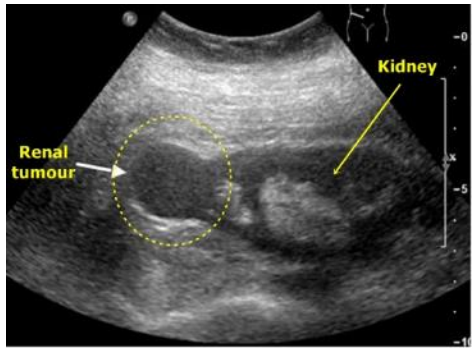


Ultrasound applications

- Gynaecology and neonatology
- Cardiology, to detect ventricular size and heart valve anomalies
- Neurology for blood flow assessment
- Nephrology (kidney, bladder)

Ultrasound systems can deliver static or dynamic images (e.g. heart valves)

Bladder with cancer



kidney with cancer

Blood vessels

Liver with cirrhosis (too much alcohol)

Ultrasound machine

Advantages include:

1. It provides images in real-time (still and video).
2. it is portable and can be brought to the bedside.
3. it is substantially lower in cost.
4. it does not use harmful ionizing radiation.

Drawbacks include:

1. various limits on its field of view including
   - patient cooperation and physique (obese).
   - difficulty imaging structures behind bone.
2. Its dependence on a skilled operator

Ultrasound Systems

- **Specialized** ultrasound systems are available per application domain, e.g. cardiovascular.
- **General purpose** ultrasound systems may differ in:
  - Different transducers
  - Color Doppler ultrasound
  - 3D-imaging capability
  - Portability

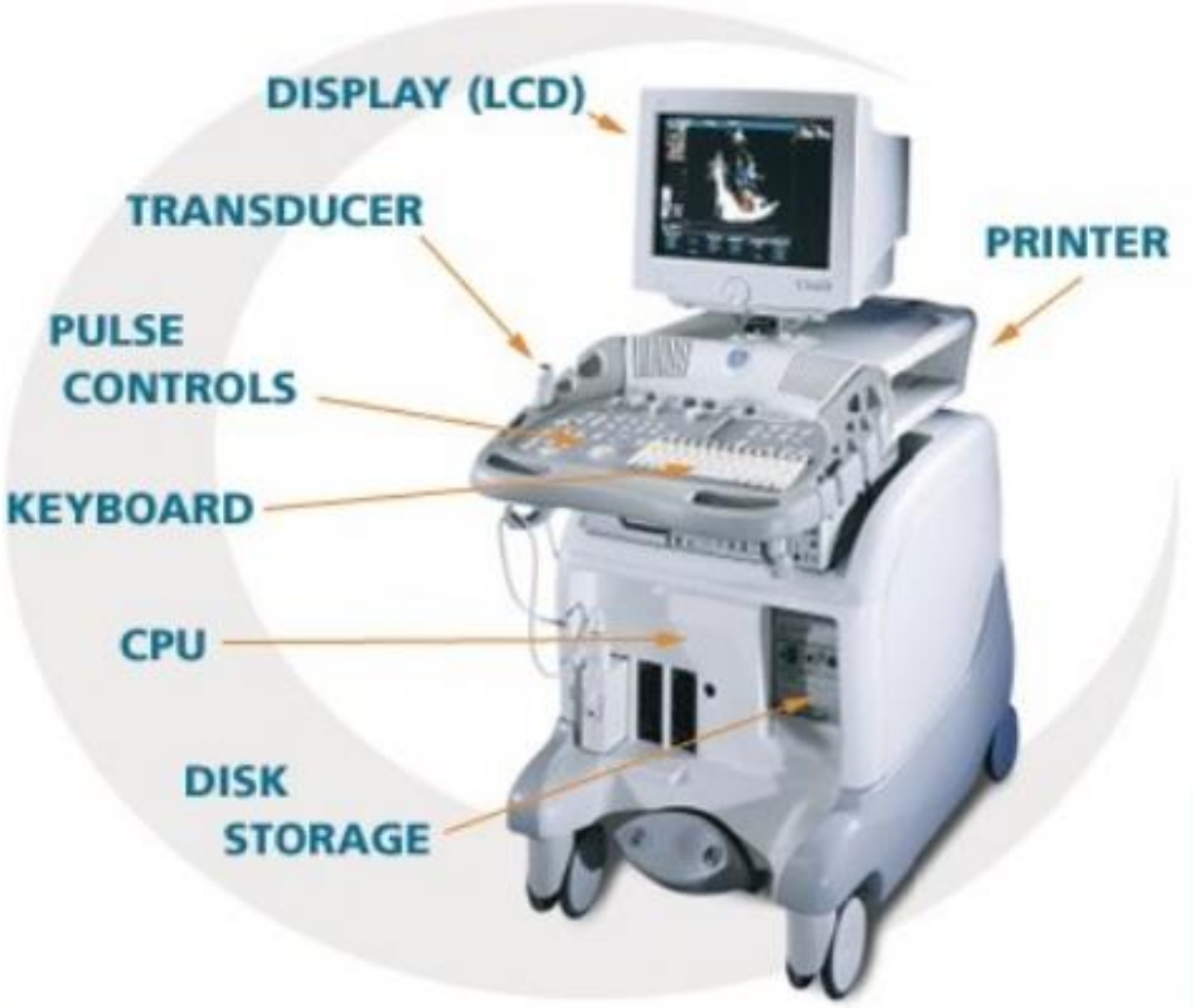
Ultrasound Systems

High end model

Black & white model

Portable model

Construction



Portable ultrasound system (examples)

Portable ultrasound system with four transducers

Ultrasound system on smart phone

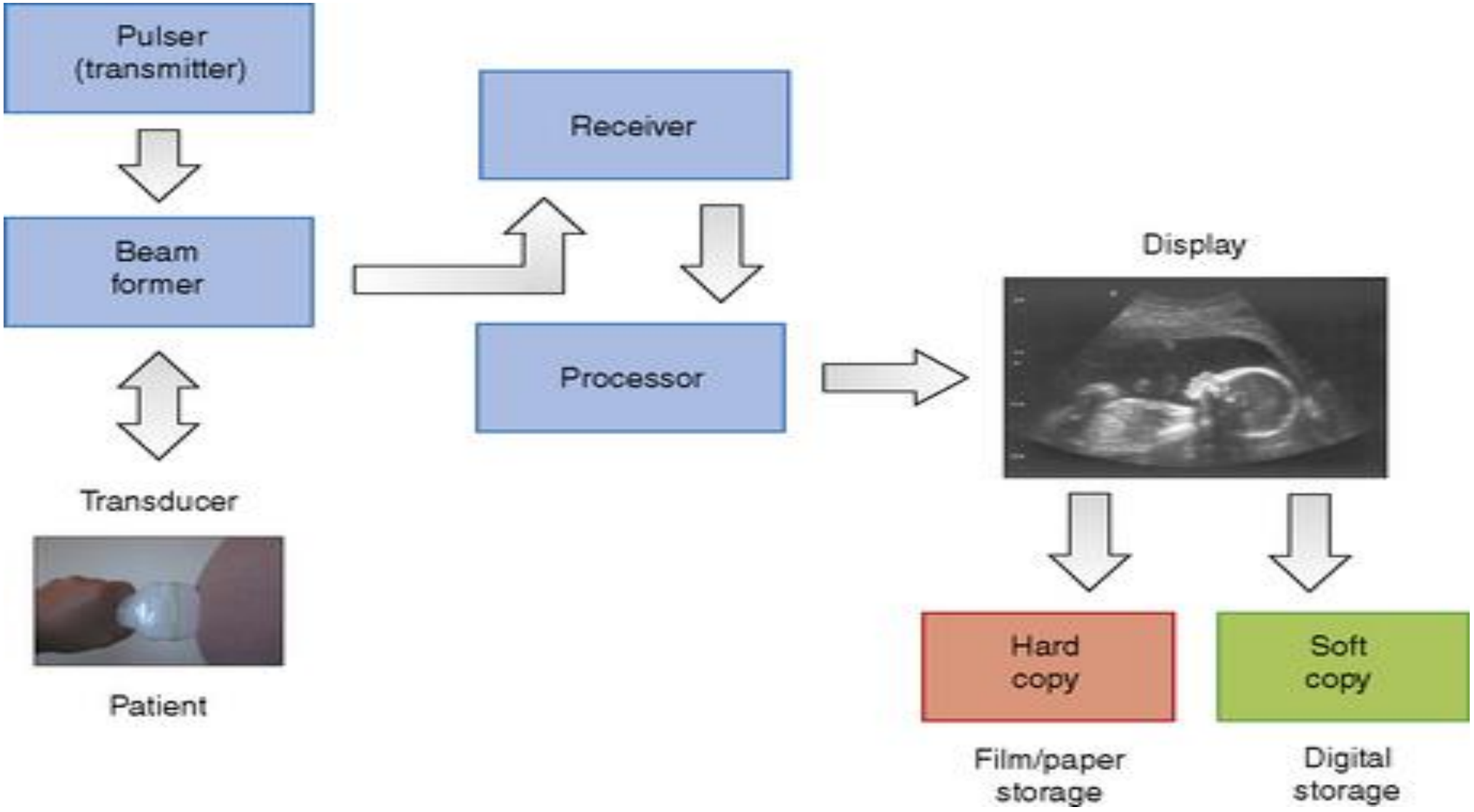
Construction

- A diagnostic ultrasound machine consists of many components, each of which has a separate operation to perform. This starts with transmitting and receiving ultrasound signals which are then processed to form the images that we see on screen.

- The internal components that make up a typical ultrasound machine are listed below:

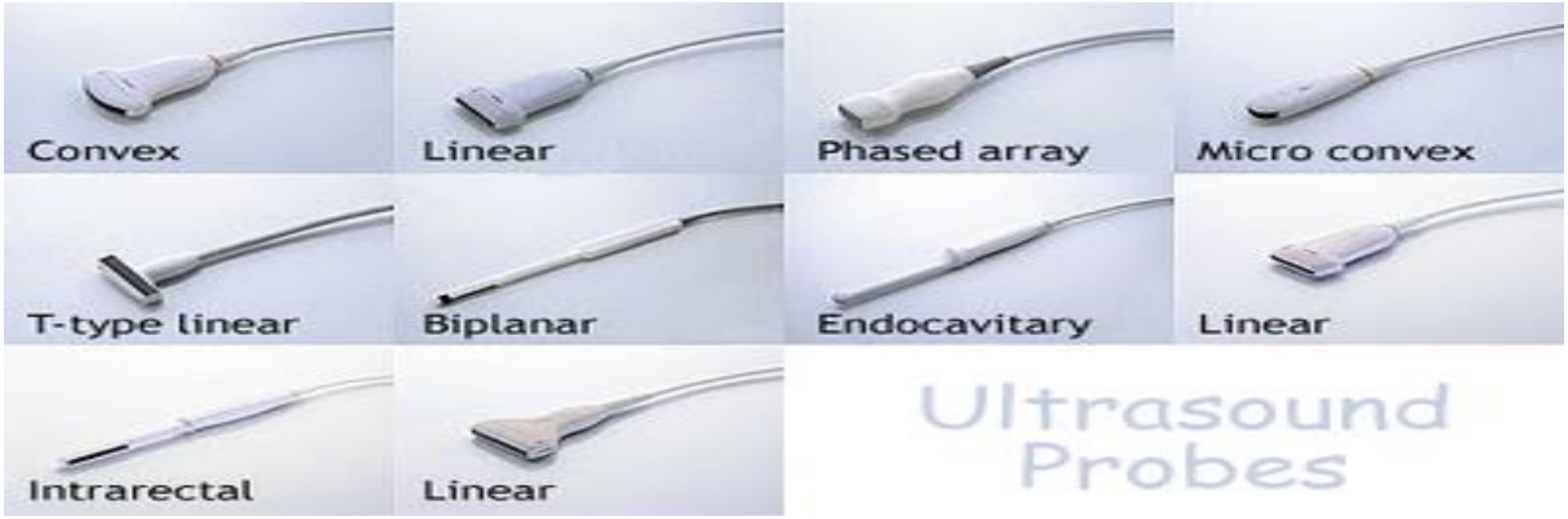
1. Transducer
2. Pulser
3. Beam former
4. Receiver
5. Processor
6. Display
7. Digital storage
8. Hard copy printer devices.

Construction



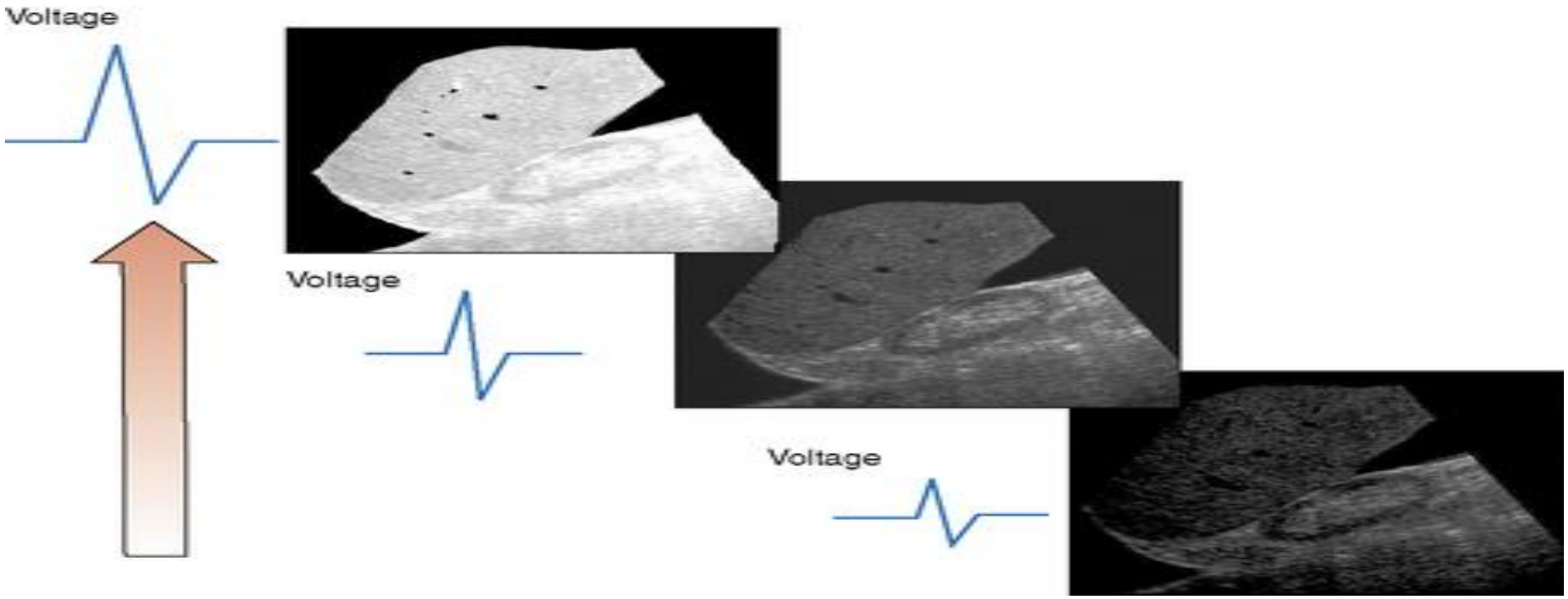
The Transducer

Diagnostic transducers are made from piezoelectric materials and are able to convert electrical energy into ultrasound energy. As a consequence of this they can act as a transmitter and receiver of ultrasound. They are able to produce beams which can be directed in various ways which are controlled by the ultrasound machine to improve image quality.



The Pulser

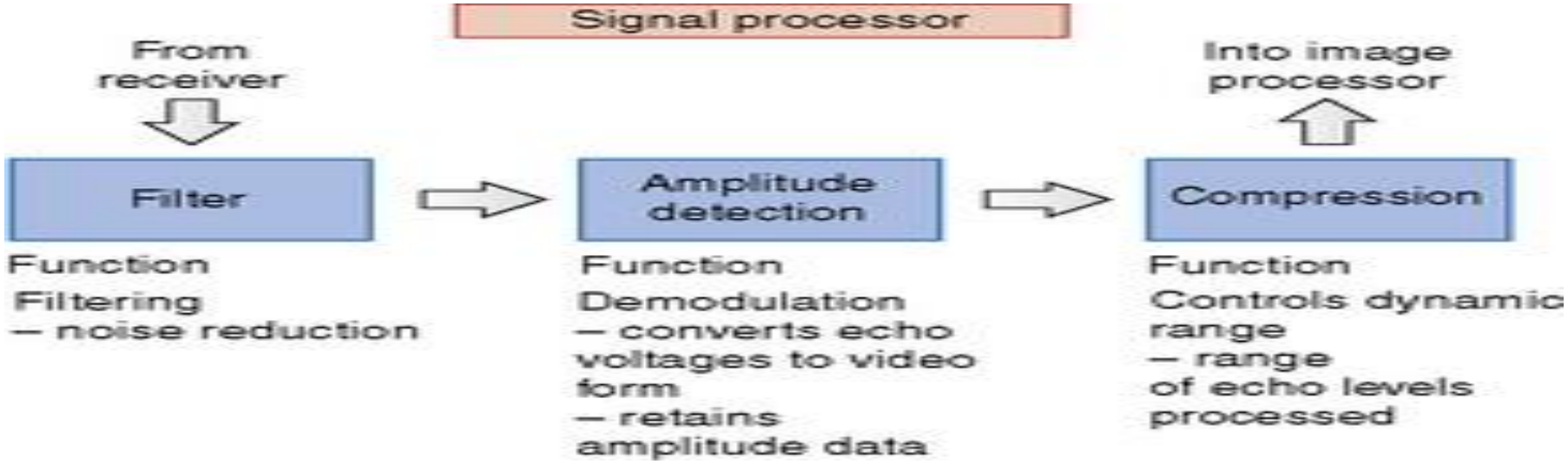
The pulser produces the electric voltage that drives the transducer. This driving voltage governs the output power of the ultrasound machine and can be adjusted by the operator through the power or output control.



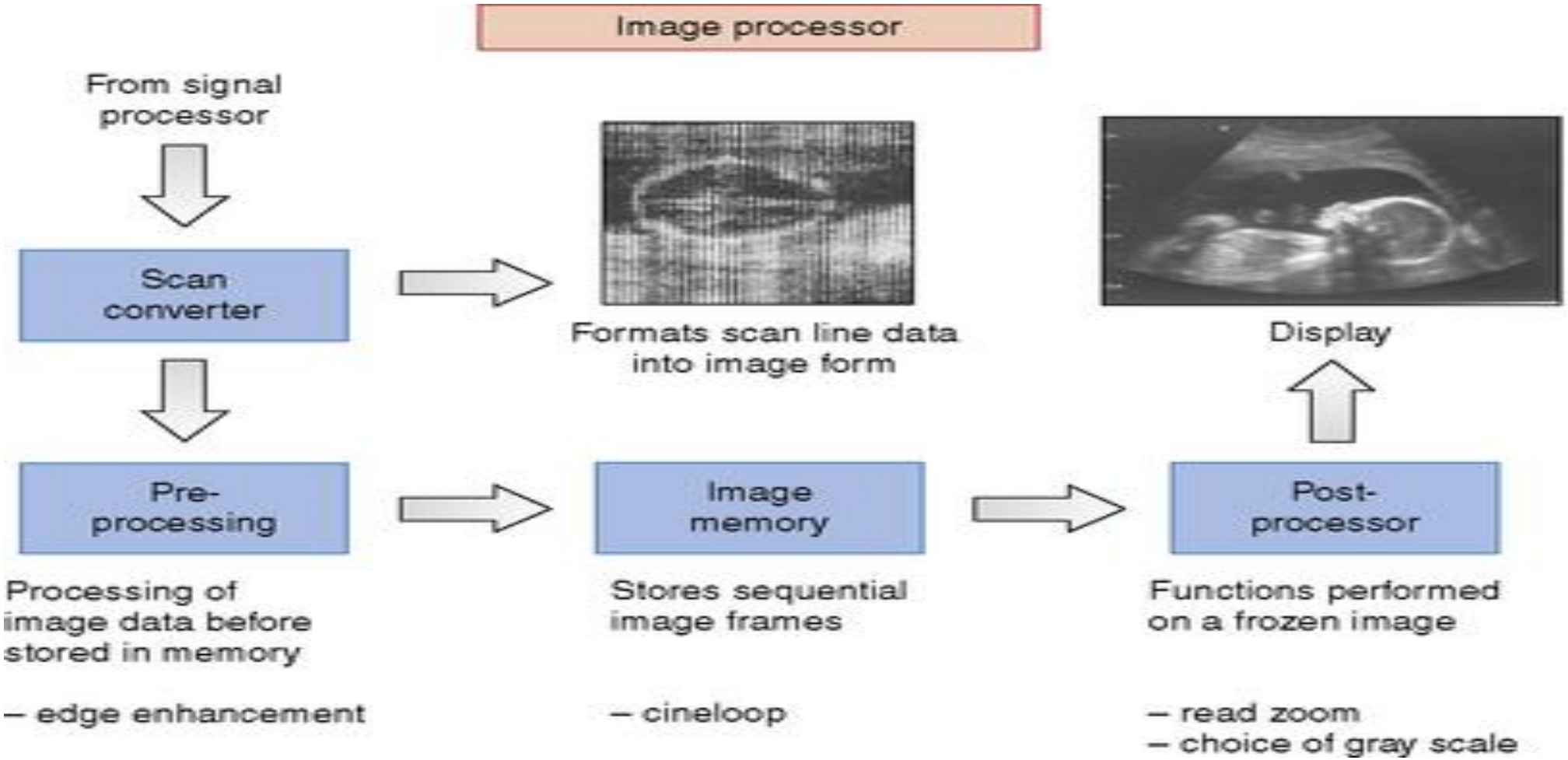
Beam Former, Receiver and Processor

- The beam former controls the shape and direction of the ultrasound beam and the scanning patterns used to form the images that we see.
- The job of the receiver is to combat attenuation.
- The processor can be divided into two individual parts:

• A signal processor – converts echo voltages to video signals
• An image processor – formats the many scan line data into image form.

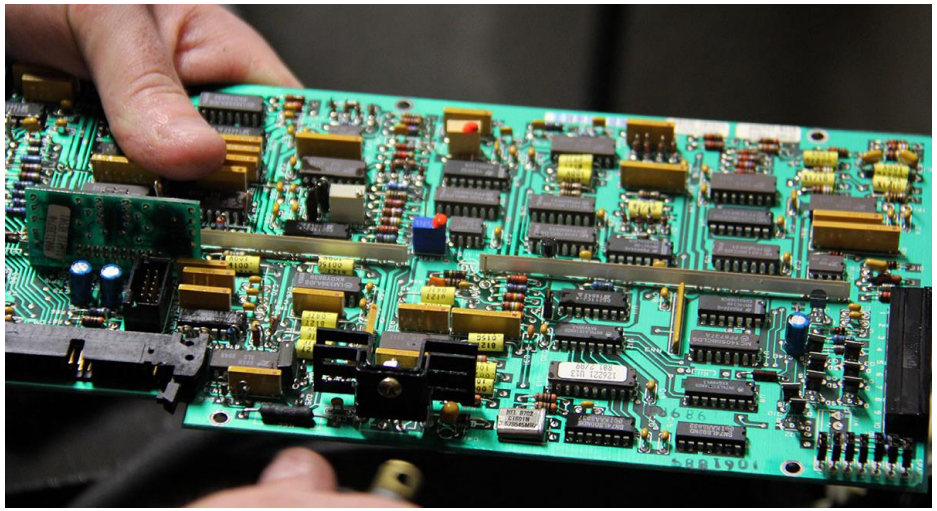


Block diagram of the signal processor



Construction

A high end ultrasound system contains a lot of electronics. Repair cannot be undertaken without guidance of a service manual. The most common problem, next to user and power issues, is poor connections of the PCBs in their connectors/slots.



Corrective Maintenance Highlights

User Error Is enough of the proper ultrasound gel used?
Are the controls set correctly? In particular the contrast and brightness buttons!

Transducer Ensure that the transducer is properly connected and undamaged
The transducer is sensitive to shocks! If there is defective element, you often see a black line on the image. Transducer cracks cannot be repaired: exchange the transducer. Gently pull on the cable at different points to see when the image flickers. This is where the cable is broken. If cable/connections are broken: fix by soldering

Dials/buttons If buttons don't function properly: replace or use anti-corrosive contact spray on dials.

Deteriorating image quality Check mains voltage, check pre-amplifiers, check probe connection, fuses.
Is the machine calibrated correctly?
the CRT (Cathode Ray Tube) monitor may be worn out after a few years. Replace! A voltage stabilizer may be required in case of varying mains voltage (more than 10%)

Electric contact Poor electric contacts is a major problem in all electronics devices.

Preventive Maintenance: Daily & Weekly care

Daily Care:

Clean Wipe dust of exterior and cover wipe probe with alcohol-free tissue or cloth

Visual Check Check all fittings and accessories are mounted correctly. Check that cables are not twisted and the probe is safely stored.

Function Check If in use that day, run a brief function check before patients arrive.

Weekly Care:

Clean Unplug, clean outside / wheels / rear with damp cloth, dry off

Visual Check Check that mains plug screws are tight. Check that mains cable has no bare wire and is not damaged.

Function Check If machine has not been in use, run and test briefly.

Do not soak the cable with gel!

Preventive Maintenance Checklist: BMET

Preventive maintenance (BMET, every six months):

Clean outside (if necessary)

Visual Check Check if all accessories are mounted correctly. Check cables, power & connections. Open system and perform visual check inside the system.

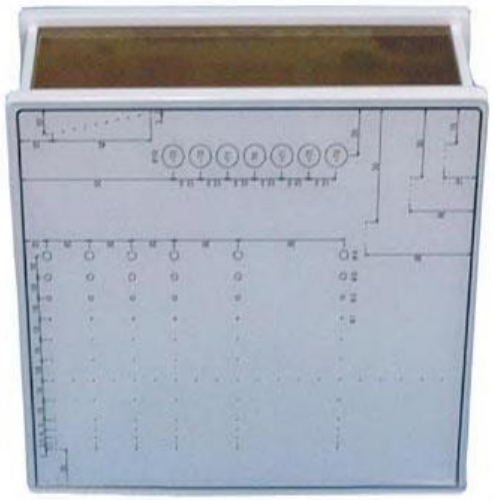
Grease & filters Clean grease wheels, replace air filters.

Function Check Check imaging quality with different transducers Calibrate system with phantoms

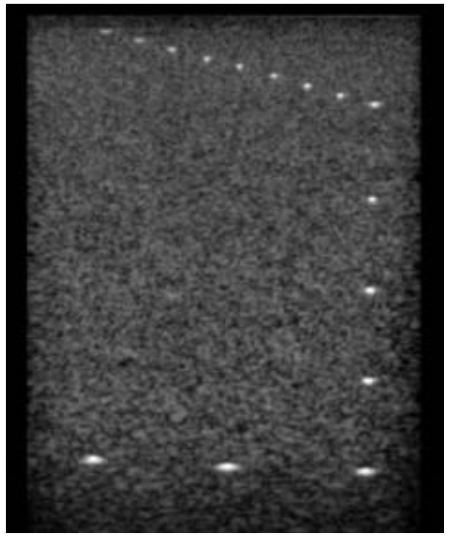
Safety Check Check electrical safety

Calibration

Calibration is performed by means of **phantoms**. Different phantoms are used to test different performance features such as lateral and axial resolution, and correctness of distance measurements. Based of the ultrasound image of the phantom, the good performance of the system can be confirmed. Transducers cannot be adjusted with respect to their image accuracy. If the test result is not acceptable, the transducer should be replaced.



Phantom (example)



Example of ultrasound image of phantom

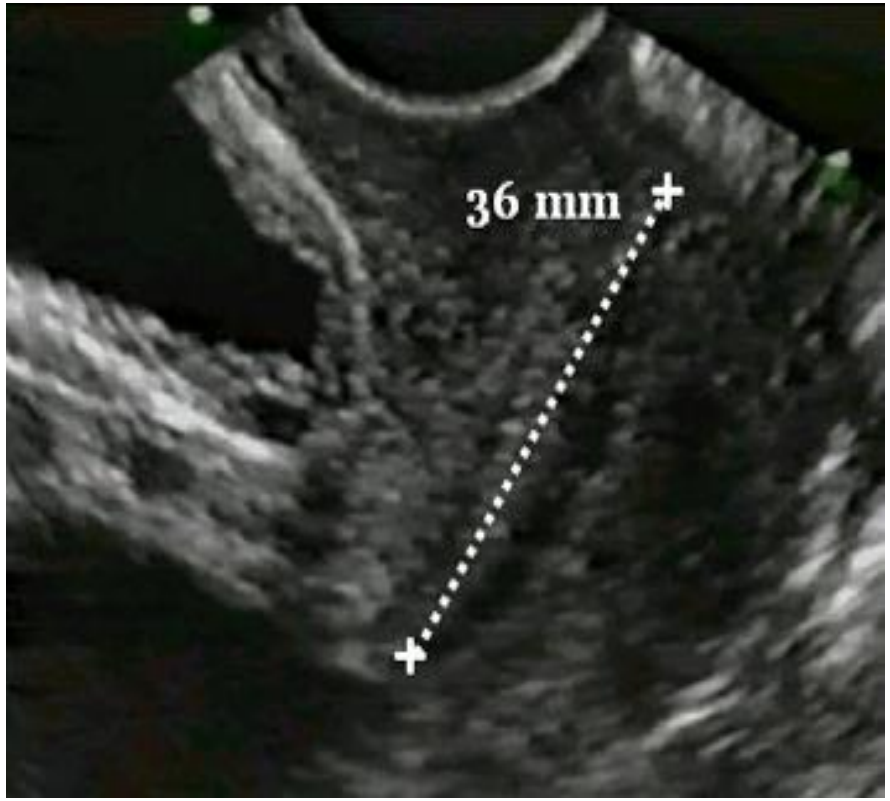
- The white dots in the image indicate reflectors at these locations in the phantom.
- If the reflections do not show up at the correct locations in the image, something is probably wrong with the transducer.

- Full calibration requires using a range of phantoms to test different aspects of the equipment.
- Follow the instructions in the service manual.

Safety

- Ultrasound diagnostic imaging appears to be risk-free when used properly.

- Ultrasound **transducers** should be handled carefully to avoid damage. Electromechanical problems, such as cracks in piezoelectric elements, can alter beam width or sound pulses, thereby affecting resolution. Errors in distance measurements from the images can cause incorrect calculations and thus an incorrect diagnosis.



THANK YOU!