Fig. 5 explains the main idea of the signal processor.

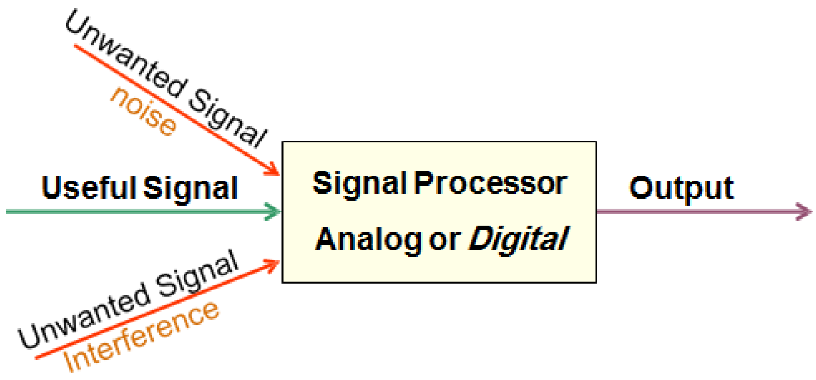

Fig. 5. Signal Processor

Analog signal processing:

Fig. 6 shows a basic block diagram of a typical analog signal processing system.

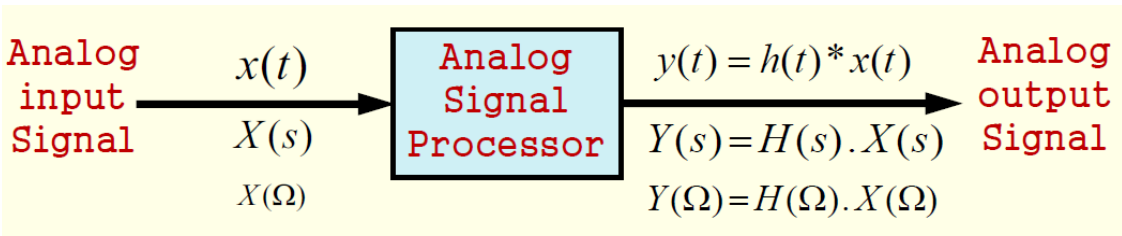

Fig. 6. A typical analog signal processing system

Where,

$h(t)$: The System Impulse Response
H(s): The System Transfer Function
H(Ω): The System Frequency Response

Analogue signal processing is achieved by using analogue components such as:

- Resistors.
- Capacitors.
- Inductors.

Limitations of analog signal processing:

- Accuracy limitations due to
  - Component tolerances
  - Undesired nonlinearities
- Limited repeatability due to
  - Tolerances
  - Changes in environmental conditions
    - Temperature
    - Vibration
- Sensitivity to electrical noise
- Limited dynamic range for voltage and currents
- Inflexibility to changes

- Difficulty of implementing certain operations
  - Nonlinear operations
  - Time-varying operations
- Difficulty of storing information

Digital signal processing (DSP) system:

Digital signal processing (DSP) is one of the most powerful technologies that will shape science and engineering in the twenty-first century. Revolutionary changes have already been made in aboard range of fields: communications, radar and sensor. DSP converts signals that naturally accrue in analog form (such as sound, video and information from sensors) to digital form and uses digital techniques to enhance and modify analog signal data for various applications. Fig. 7 shows a basic block diagram of a typical digital signal processing system.

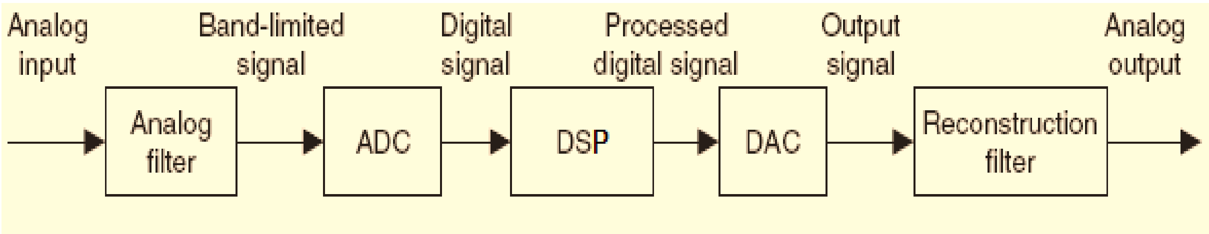

Fig. 7. A typical digital signal processing (DSP) system

The system consists of an analog filter, an analog-to-digital conversion (ADC) unit, a digital signal processor (DSP), a digital-to-analog conversion (DAC) unit, and a reconstruction (anti-image) filter.

As shown in the diagram, the **analog input signal**, which is continuous in time and amplitude, is generally encountered in our real life. Examples of such analog signals include current, voltage, temperature, pressure, and light intensity. Usually a transducer (sensor) is used to convert the non-electrical signal to the analog electrical signal (voltage). This analog signal is fed to an **analog filter**, which is applied to limit the frequency range of analog signals prior to the sampling process. The purpose of filtering is to significantly attenuate aliasing distortion.

The band-limited signal at the output of the analog filter is then sampled and converted via the **ADC** unit into the digital signal, which is discrete both in time and in amplitude.

The **DSP** then accepts the digital signal and processes the digital data according to DSP rules such as lowpass, highpass, and bandpass digital filtering, or other algorithms for different applications. Notice that the DSP unit is a special type of digital computer and can be a general-purpose digital computer, a microprocessor, or an advanced microcontroller; furthermore, DSP rules can be implemented using software in general. With the DSP and corresponding software, a processed digital output signal is generated. This signal behaves in a manner according to the specific algorithm used.

The **DAC** unit converts the processed digital signal to an analog output signal. The signal is continuous in time and discrete in amplitude (usually a sample-and-hold signal).

The final stage in Fig. 7 is often another **analog filter** designated as a function to smooth the DAC output voltage levels back to the analog signal (i.e. to reconstruct the analog signal from the DAC output).

In contrast to the above, a direct analog processing of analog signals is much simpler since it involves only a signal processor. It is therefore natural to ask why we go to use the DSP systems. There are several good reasons:

1- Rapid advances in integrated circuit design and manufacture are producing more powerful DSP systems on a single chip at decreasing size and cost.
2- Digital processing is inherently stable and reliable.
3- Good processing techniques are available for digital signals, such as Data compression (or source coding), Error Correction (or channel coding), Equalization and Security.
4- Easy to mix signals and data using digital techniques known as Time Division Multiplexing (TDM).
5- It is easy to Change, Correct, or Update applications (software changes), such as-that needed in implementing adaptive circuits.
6- Sensitivity to electrical noise is minimal.
7- Digital information can be encrypted for security.

The list below by no means covers all DSP applications. Many more areas are increasingly being explored by engineers and scientists. Applications of DSP techniques will continue to have profound impacts and improve our lives.

1- *Digital audio and speech*: Digital audio coding such as CD players, digital crossover, digital audio equalizers, digital stereo and surround sound, noise reduction systems, speech coding, data compression and encryption, speech synthesis and speech recognition.
2- *Digital telephone*: Speech recognition, high-speed modems, echo cancellation, speech synthesizers, DTMF (dual-tone multi frequency) generation and detection, answering machines.

3- *Automobile industry*: GPS, Active Noise Cancellation, Cruise Control, Parking.

4- *Electronic communications*: Cellular phones, digital telecommunications, wireless LAN (local area networking), satellite communications.

5- *Medical imaging equipment*: ECG analyzers, cardiac monitoring, medical imaging and image recognition, digital x-rays, image processing, magnetic resonance, tomography and electrocardiogram.

6- *Multimedia*: Internet phones, audio, and video, hard disk drive electronics, digital pictures, digital cameras, DVD, JPEG, Movie special effects, video conferencing, text-to-voice and voice-to-text technologies.

7- *Military*: Radar, sonar, space photographs, remote sensing.

8- *Mechanical*: Motor control, process control, oil and mineral prospecting.