# ULTRASOUND IMAGING SYSTEM FOR DIAGNOSTIC APPLICATIONS

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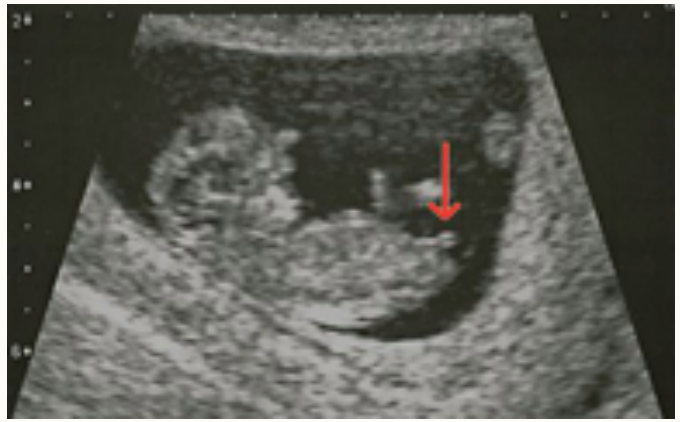
# Introduction

- Ultrasound Imaging is diagnostic Imaging technique using ultrasound waves
- It is used to visualise body structures like muscles, joints, vessels and internal organs such as heart, kidney etc.
- Structures like muscles, joints etc are imaged at a frequency around 7-18 MHz
- Deeper structures such as liver and kidney are imaged at lower frequencies: 1-6 MHz

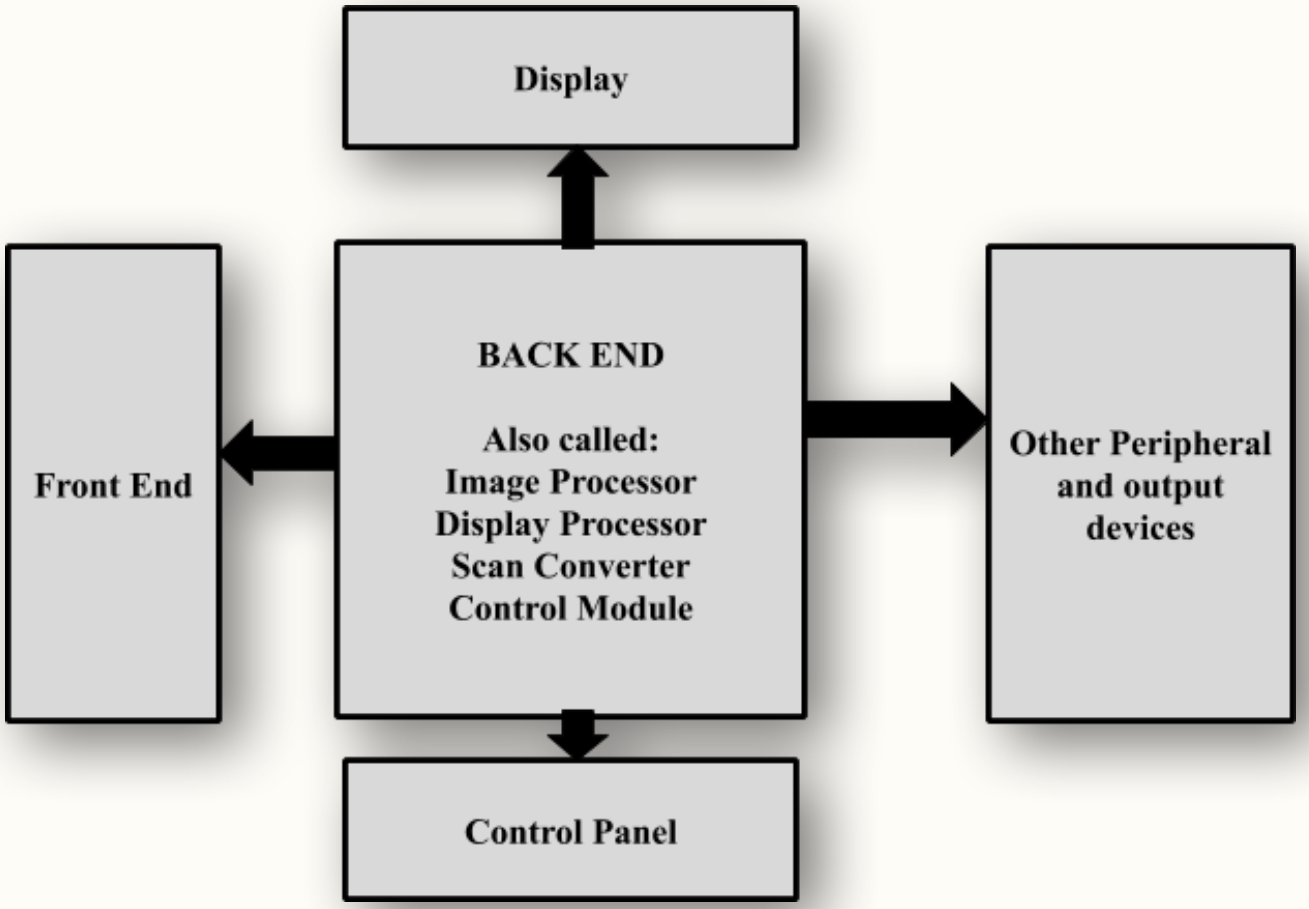
# Principle



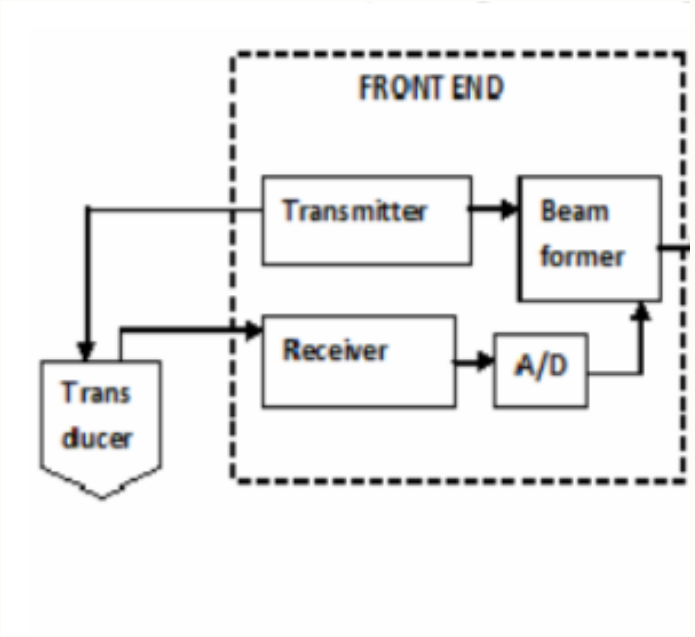
Ultrasound Image

- The Ultrasound wave travels into the body
- Some of the energy in the wave generates an echo due to reflection process
- Wave is reflected anywhere there are density changes in the body. Some of the reflections return to the transducer
- The return wave vibrates the transducer, which turns the vibrations into electrical pulses that travel to the ultrasonic scanner where they are processed and transformed into a digital image.
- The ultrasound image consists of a 2D representation of the echo pattern in a cross-section of tissue with the transducer position at the top of the image. The locations of echo-producing tissue interfaces are represented by bright pixels on a dark background.

# Block Diagram




- Front End System: It synchronises the generation of ultrasound waves
- Front End System consists of transducer, pulser i.e voltage generator for transducer, transmitter and receiver, A/D convertor etc.



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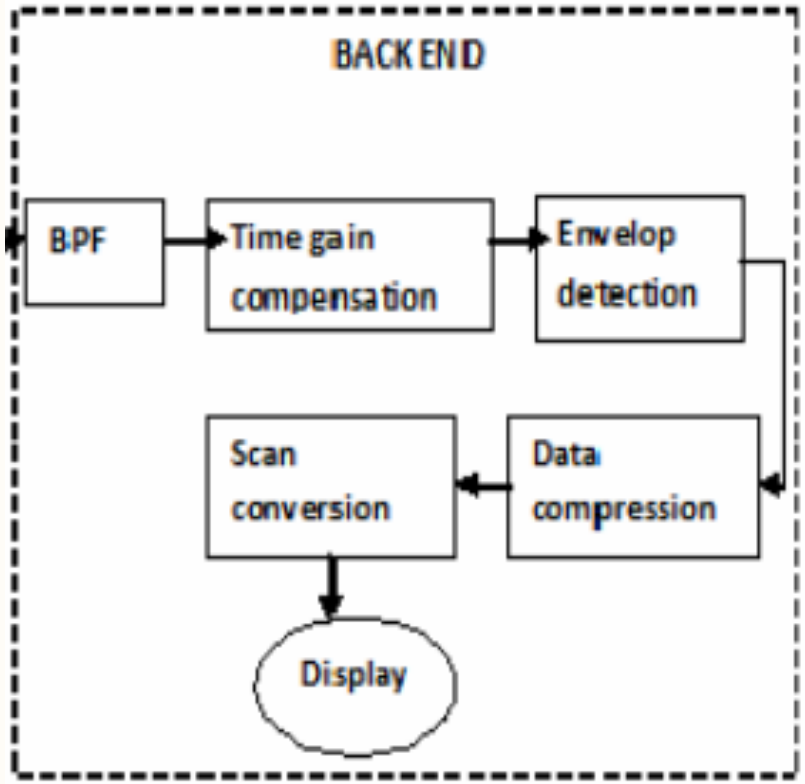



Components of Back End System

- Output of front end system is provided to Backend System
- Backend System: This part performs some signal processing to make the data fit the human eye perception.

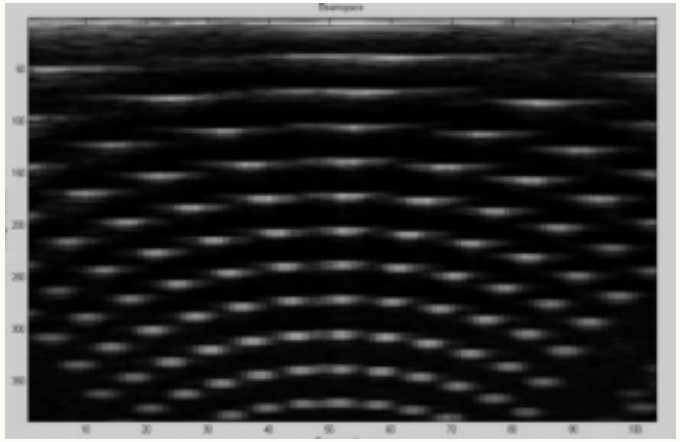
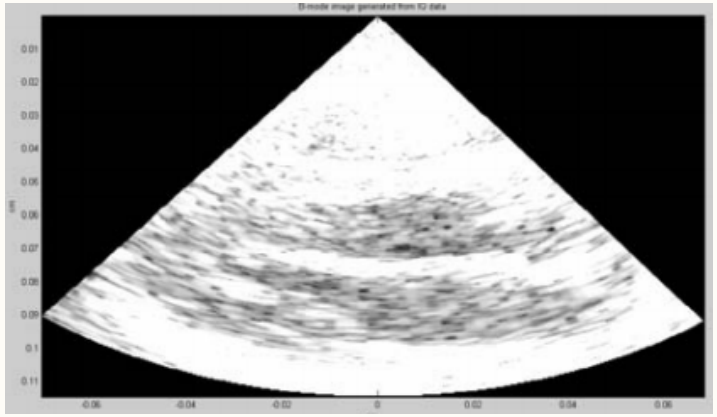


Image before Scan Conversion



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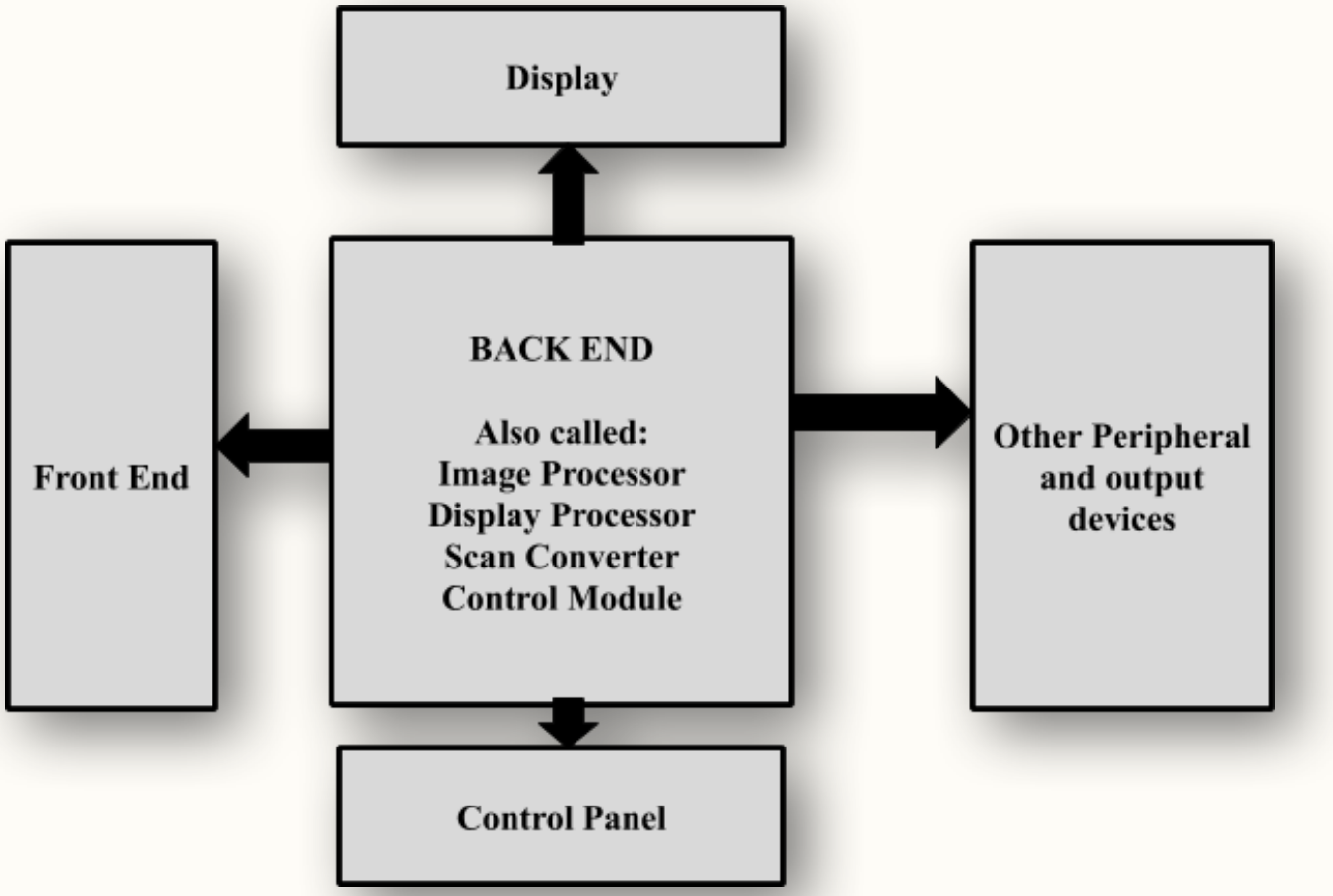
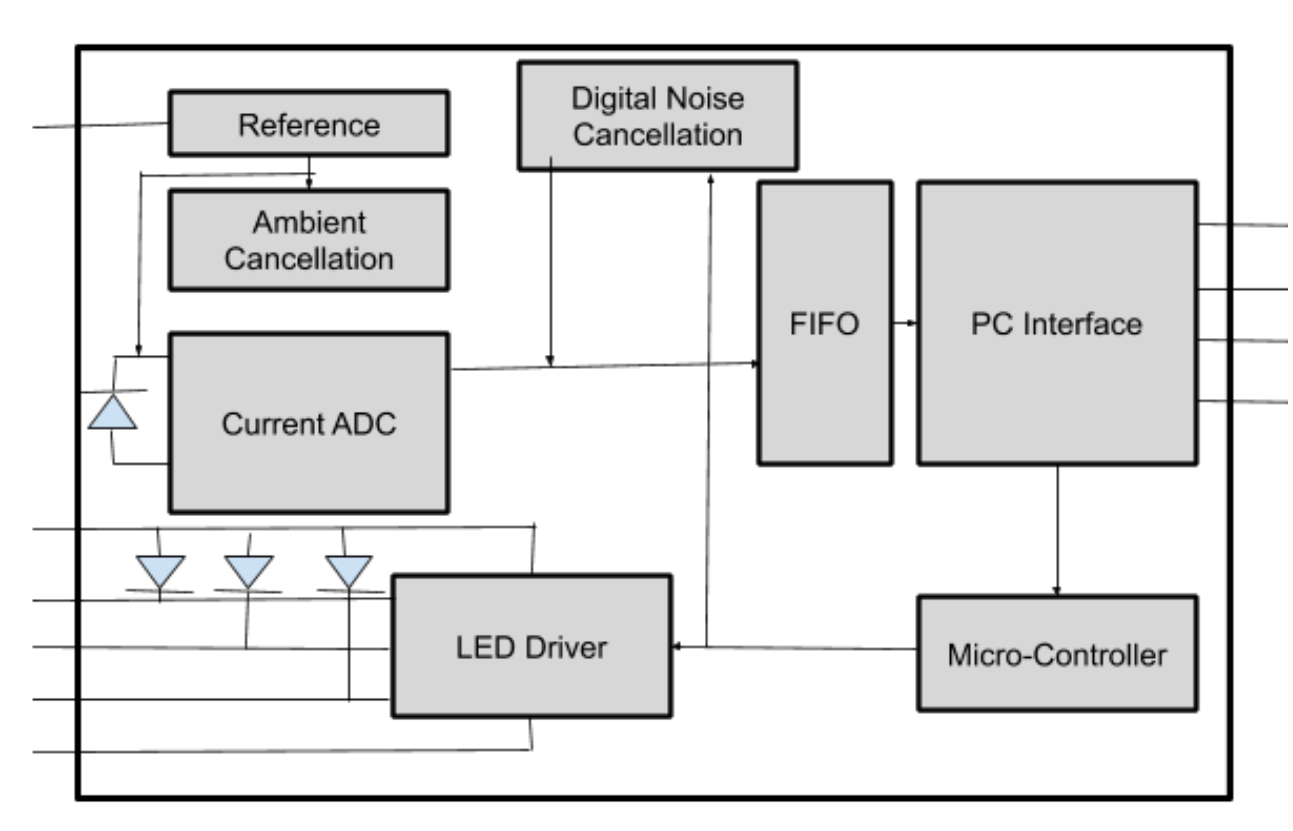



- Display (System monitoring): This system monitor is an RGB display monitor with an integrated microphone.
- Control Panel: It mainly consists of user input peripheral devices such as keyboard, trackball, microphone, foot switch, touch panels.
- Other Peripherals and Output devices: It includes printers, speakers networks and other ports.

# Architectural Design

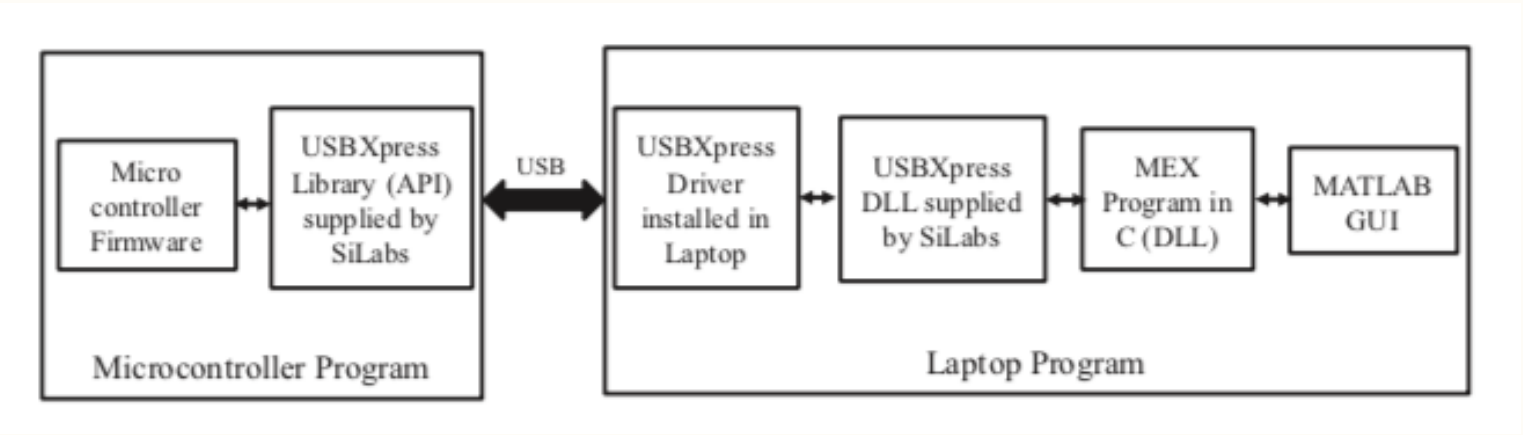



**Microcontroller:**

- Many micro-controllers such as silicon lab's C8051F340 or STM32 can be used for ultrasound imaging applications.
- The image and video processing algorithms like smoothening, sharpening etc. are performed by interfacing MATLAB and the micro-controller.

# Architectural Design

## Interfacing C8051F340 micro-controller:

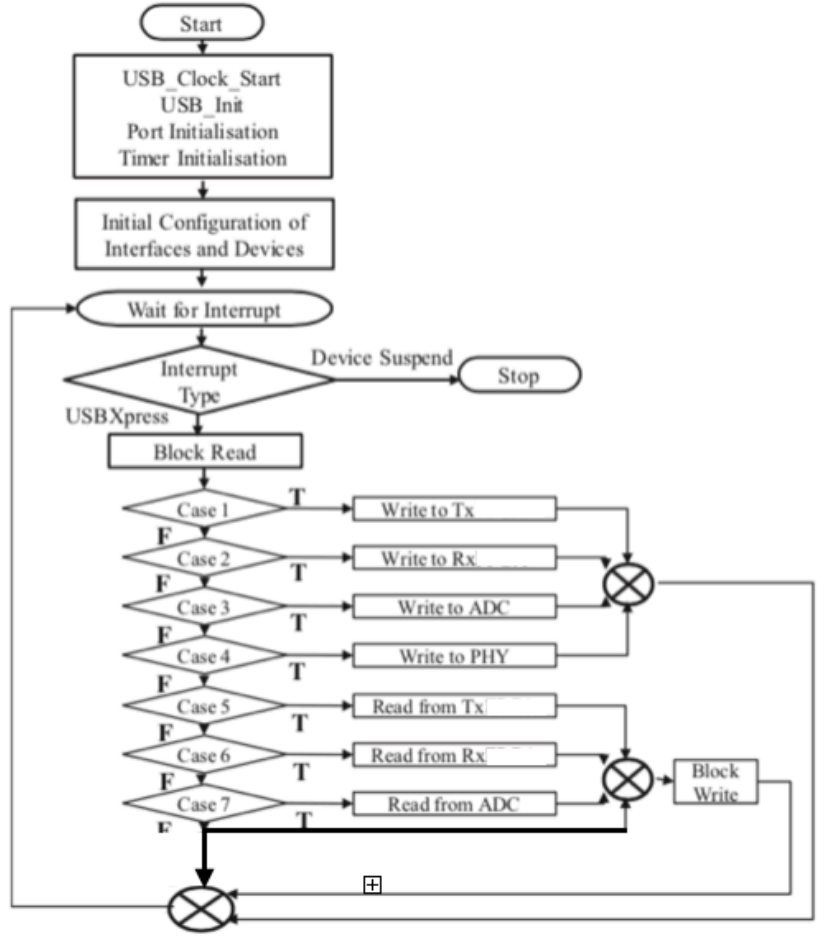



USB DLL interface functions.

| Function name | Function |
|---|---|
| SI_GetNumDevices | Returns the number of devices connected |
| SI_GetProductString | Returns a descriptor for a device |
| SI_Open | Opens a device and returns a handle |
| SI_Close | Cancels pending IO and closes the device |
| SI_Read | Reads a block of data from the device |
| SI_Write | Writes a block of data to the device |
| SI_SetTimeouts | Sets read and write block timeout |
| SI_CheckRXQueue | Gets the number of bytes in the device Rx Queue |

USB API device interface functions.

| Function name | Function |
|---|---|
| USB_Clock_Start | Initializes the USB clock |
| USB_Init | Enables the USB interface |
| Block_Write | Writes a buffer of data to the host via USB |
| Block_Read | Reads a buffer of data from the host via USB |
| USB_Int_Enable | Enables API interrupts |
| USB_Disable | Disables USB interface |
| USB_Suspend | Suspends the USB interface |



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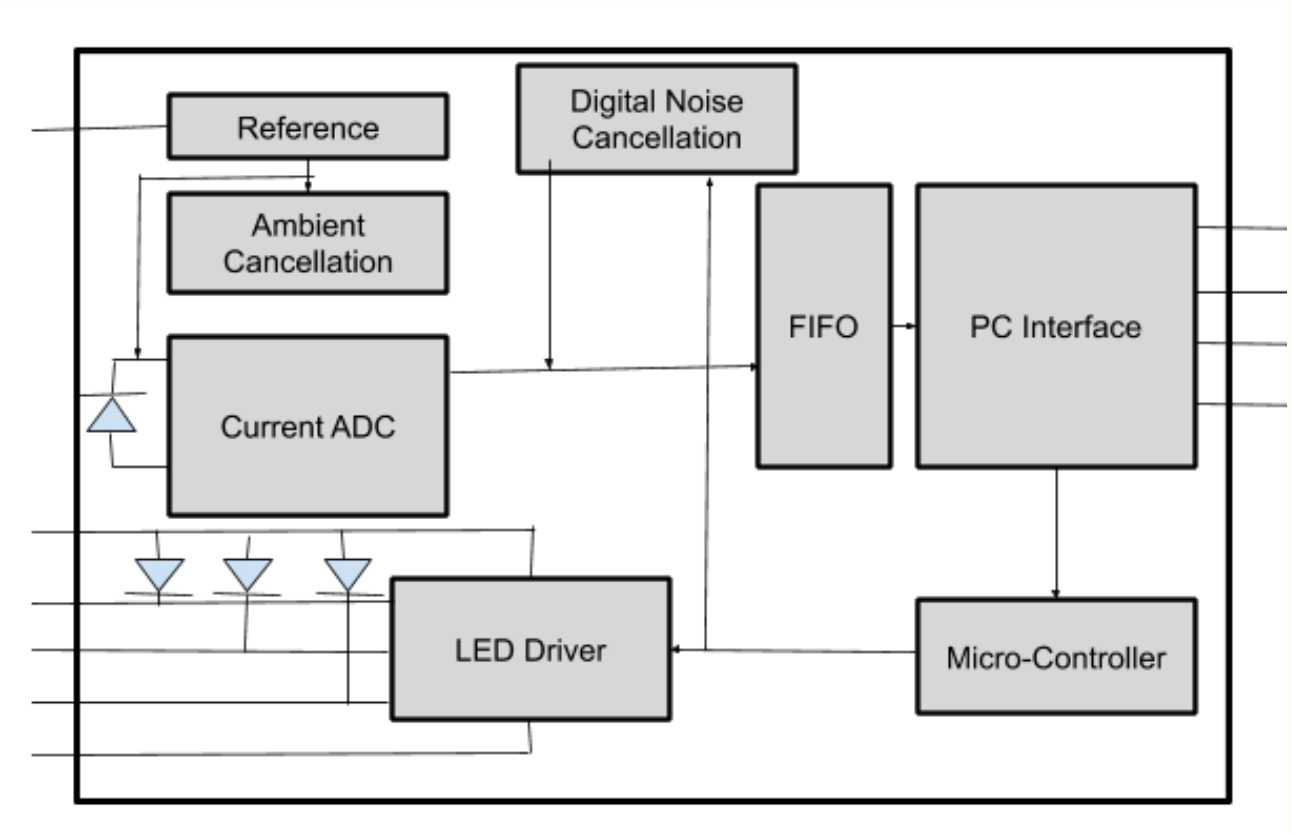
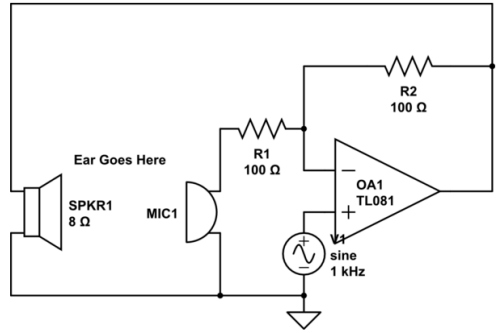
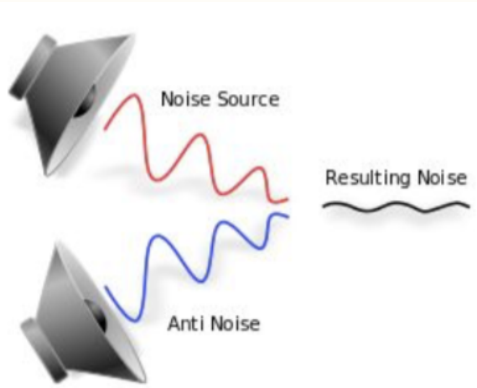


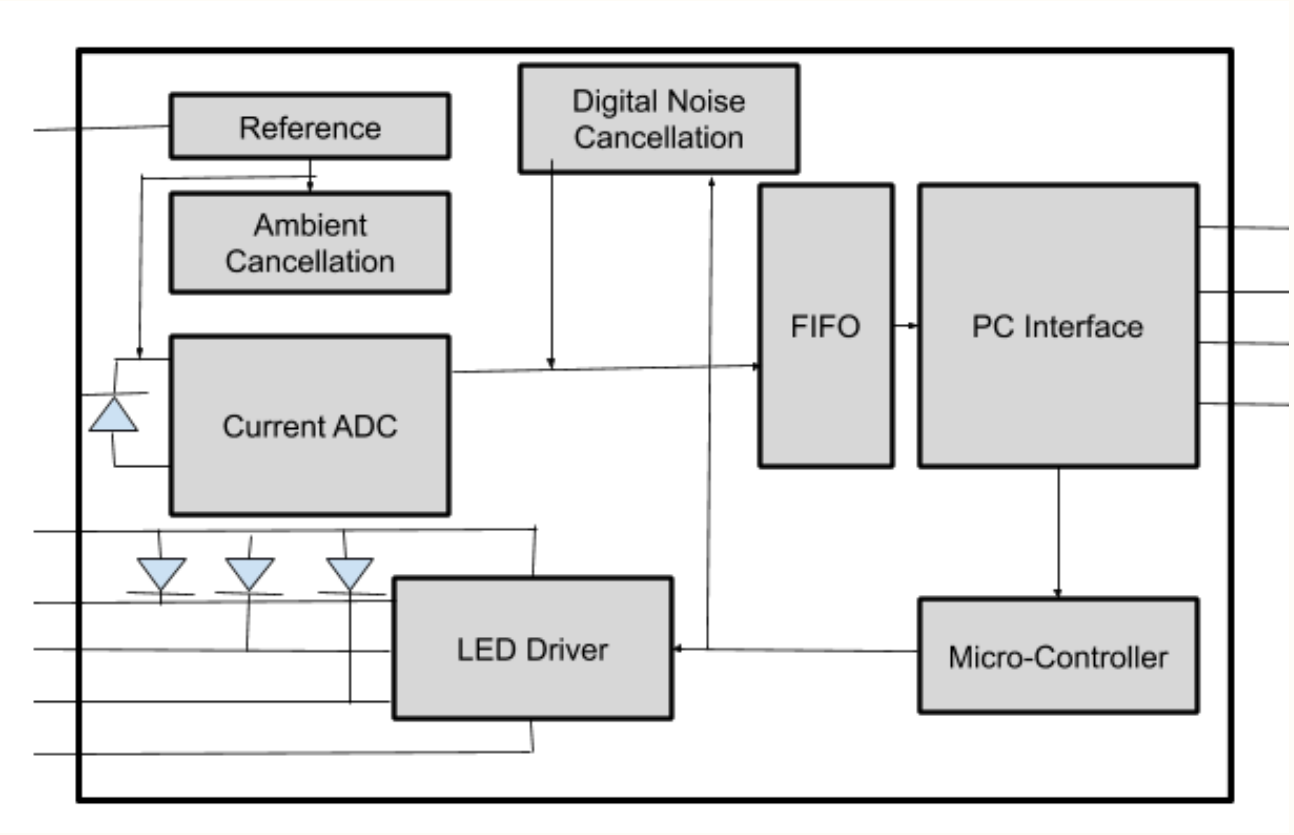

**Ambient Cancellation:**

- Cancels background noise
- It emits a sound wave with the same amplitude but with inverted phase to the original sound leading to destructive interference.
- It consists of various op-amps, resistors etc.



# Architectural Design




**Digital Noise Cancellation:**

- Digital Noise: visual distortion
- It can be removed by convolving the original image with a mask that represents a low-pass filter.

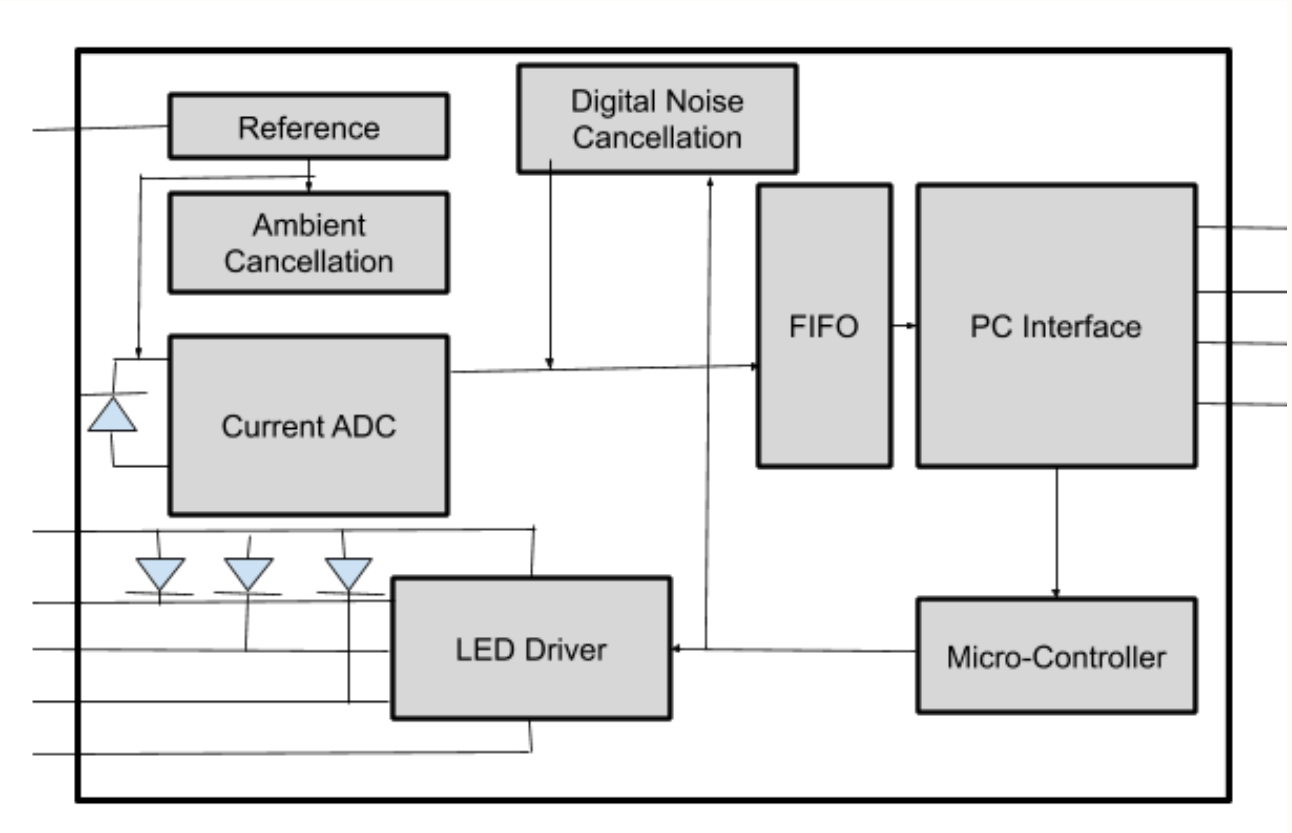
**Current ADC:**

- It converts an input analog current to a digital number representing the magnitude of that current.

**FIFO (First In First Out):**

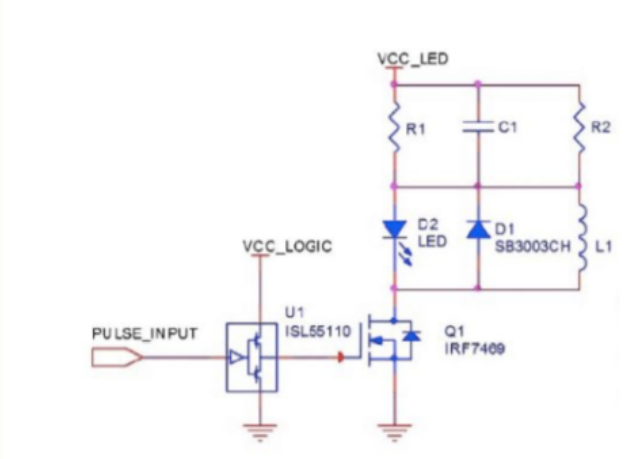
- It acts as intermediate storage when data arrives at the receiving subsystem at a high rate but can then only be processed slowly. The first data written into a FIFO is also the first to leave it at readout.

# Architectural Design




**LED Driver:**

- required to convert the alternating current from the power supply to the regulated voltage direct current used by the LEDs




**PC Interface:**

- It acts as a central processing unit. It performs processing of image data

# Diagnostic Applications

- In the field of obstetrics and gynaecology:
- Monitoring the baby for various procedures
- Measuring the size of the foetus
- In the field of Urology:
- Measuring blood flow through the kidney
- Locating kidney stones
- In the field of cardiology
- Seeing the inside of the heart to identify abnormal function
- Measuring blood flow through the heart and major blood vessels

# Risks involved

The two major risks involved with Ultrasound are:

- Development of heat: Sometimes tissues or water absorb the ultrasound energy which increases their temperature locally, leading to development of heat.
- Formation of bubbles (cavitation): When dissolved gases come out of solution due to local heat caused by Ultrasound, bubbles are formed.

# Benefits

- It images muscles and soft tissues very well.
- Ultrasound systems render live images where the most desirable section is selected.
- It shows the structure of organs.
- It has no long-term side-effects.
- It is widely available,comparatively flexible, relatively inexpensive and highly portabl
- It’s spatial resolution is better in high frequency ultrasound scanners.

# Limitations

- ls Ultrasound Imaging devices have trouble penetrating bone.
- It performs very poorly when there is a gas between the transducer and organ of interest.
- Body habitus has a large influence on image quality.
- This method is operator-dependent.