S/H circuits & A/D Converters

CSE 211

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Analog to Digital Conversion

- Modern day electronics is purely digital. Unfortunately for digital systems, the world we live in is still analog and full of colour, not just black and white.
- For example, a temperature sensor like the LM35 outputs a voltage dependent on the temperature, in case of that specific device 10mV = per degree rise in temperature. If we directly connect this to a digital input, it will register either as a high or a low depending on the input thresholds, which is completely useless. Instead we use an Analog to Digital converter to convert the analog voltage input to a series of bits that can be directly connected to the data bus of the microprocessor and used for computation.

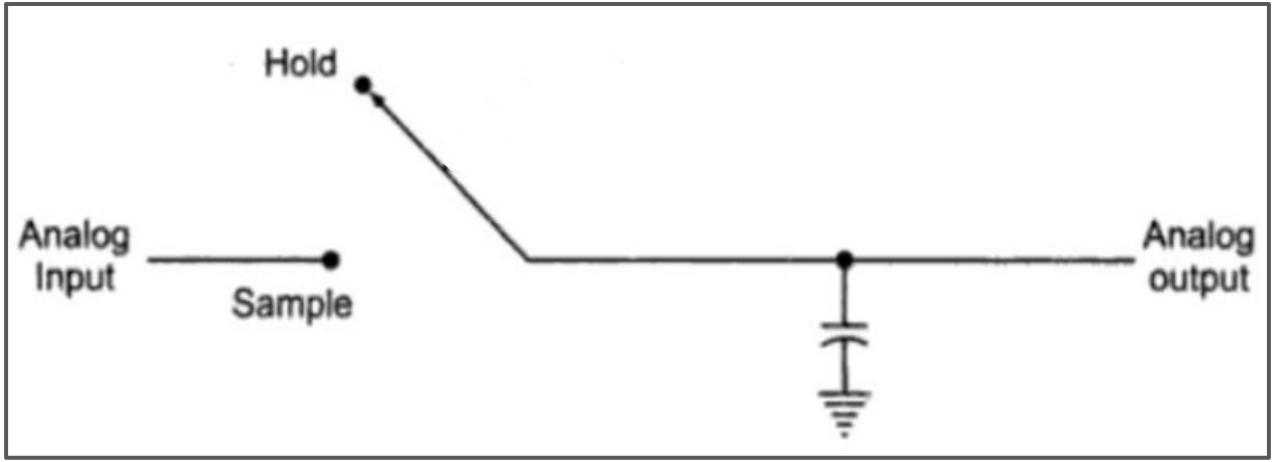
Sample and Hold Circuit

- A Sample and Hold Circuit, sometimes represented as S/H Circuit or S & H Circuit, is usually used with an Analog to Digital Converter **to sample the input analog signal and hold the sampled signal**. They are a critical part of Analog to Digital Converters and help in accurate conversion of analog signals to digital signals.
- In the S/H Circuit, **the analog signal is sampled for a short interval of time**, usually in the range of 1μS to 10μS. After this, **the sampled value is hold until the arrival of next input signal to be sampled**. The duration for holding the sample will be usually between few milliseconds to few seconds. For the ADC to produce accurate results, the input analog voltage should be held constant for the duration of the conversion.
- As the name suggests, a S/H Circuit samples the input analog signal based on a sampling command and holds the output value at its output until the next sampling command is arrived.

Simple Sample and Hold Circuit

The operating principle of a S/H Circuit is shown below in a simplified circuit diagram. The following image shows a basic S/H Circuit. This sample and hold circuit consist of two basic components: **Analog Switch and Holding Capacitor**

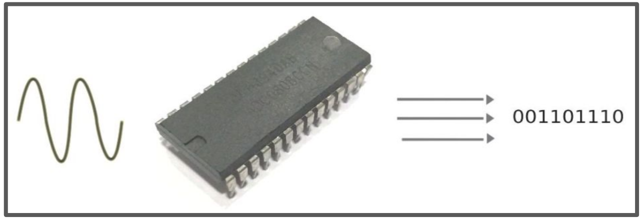
This circuit tracks the input analog signal until the sample command is changed to hold command. After the hold command, the capacitor holds the analog voltage during the analog to digital conversion.



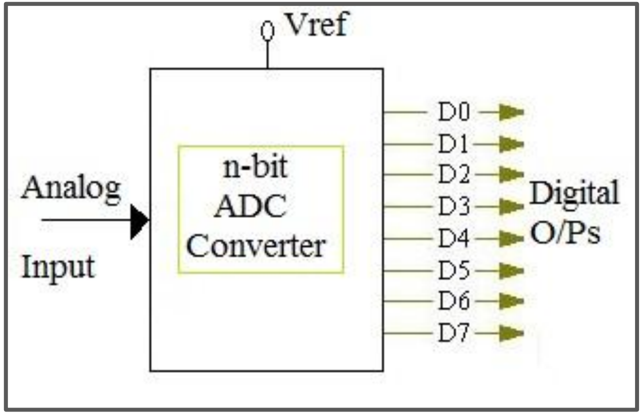
Analog to Digital Converter (ADC)

An analog to digital converter is a circuit that **converts a continuous voltage value (analog) to a binary value (digital).** It is an electronic device used for converting an analog signal into a digital signal. These ADC circuits can be found as an individual ADC ICs by themselves or embedded into a microcontroller.

The analog input signal of ADC is **continuous time & continuous amplitude signal.** The output of ADC is a **discrete time and discrete amplitude** digital signal.



In the real world, every real quantity such as voice, temperature, light, etc exists in the analog state. And it cannot be directly processed by any digital device such as a computer or a cell phone. These analog quantities are converted into digital form so that a digital device can process it. This conversion is done using a analog to digital converter.



Block Diagram of ADC

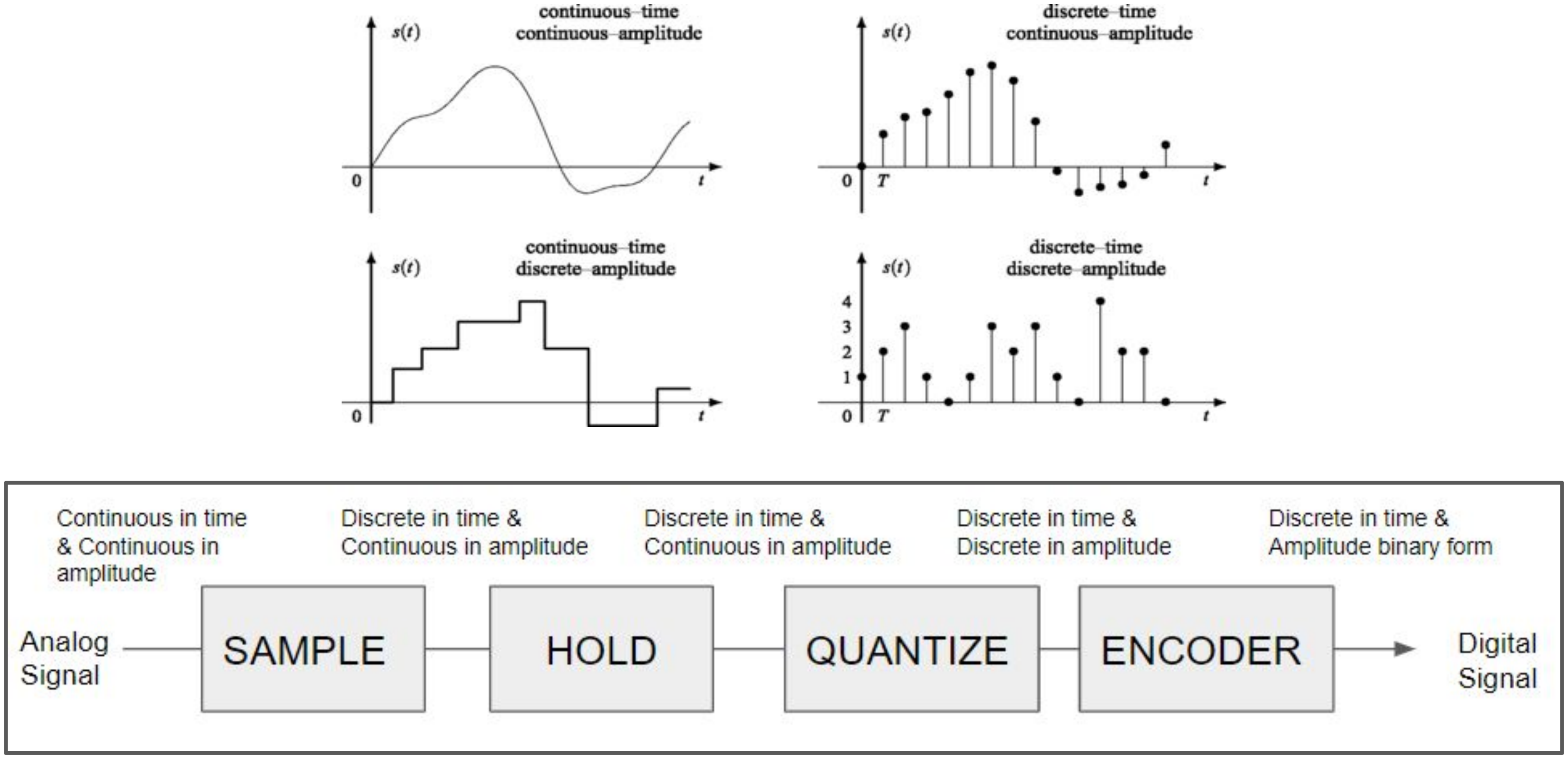


Figure: Block diagram of ADC

Conversion Steps

The analog signal is first applied to the ‘sample‘ block where it is sampled at a specific sampling rate. The sample amplitude value is maintained and held in the ‘hold‘ block. It is an analog value. The hold sample is quantized into discrete value by the ‘quantize‘ block. At last, the ‘encoder‘ converts the discrete amplitude into a binary number.

Analog To Digital Conversion Steps

The conversion from analog signal to a digital signal in an analog to digital converter is explained below using the steps mentioned in the block diagram of ADC.

Sample

The sample block’s function is **to sample the input analog signal at a specific time interval**. The samples are taken in continuous amplitude & possess real value but they are discrete with respect to time. The sampling rate plays important role in the conversion. So sampling is always maintained at a specific rate. The sampling rate is set according to the requirement of the system.

Conversion Steps

Hold

The second block used in ADC is the ‘Hold’ block. It **only holds the sample amplitude** until the next sample is taken. The hold value remains unchanged till the next sample.

Quantize

This block is used for quantization. It **converts the analog or continuous amplitude into discrete amplitude.** The on hold continuous amplitude value in hold block goes through ‘quantize’ block & becomes discrete in amplitude. The signal is now in digital form as it has discrete time & discrete amplitude.

Encoder

The encoder block **converts the digital signal into binary form**. As we know that the digital devices operate on binary signals so it is necessary to convert the digital signal into the binary form using the Encoder.

This is the whole process of converting an analog signal into a digital form using an Analog to Digital Converter. This whole conversion occurs in a microsecond.

Applications

The applications of ADC are limitless. Some of these applications given below:

- Cell phones operate on the digital voice signal. Originally the voice is in analog form, which is converted through ADC before feeding to the cell phone transmitter.
- ADCs may also be used to convert analog audio streams. For example, if you want to record sounds from a microphone, the audio must be converted from the microphone's analog signal into a digital signal that the computer can understand.
- Almost all modern microcontrollers have a built in ADC, the most common being the Arduino based on the ATMega328P with a 10 bit resolution.
- Most power supplies these days are computer controlled, and for the computer to measure the voltage output an ADC is needed.
- Air conditioner contains temperature sensors for maintaining the room temperature. This temperature is converted into digital form using ADC so that onboard controller can read & adjust the cooling effect.

The End