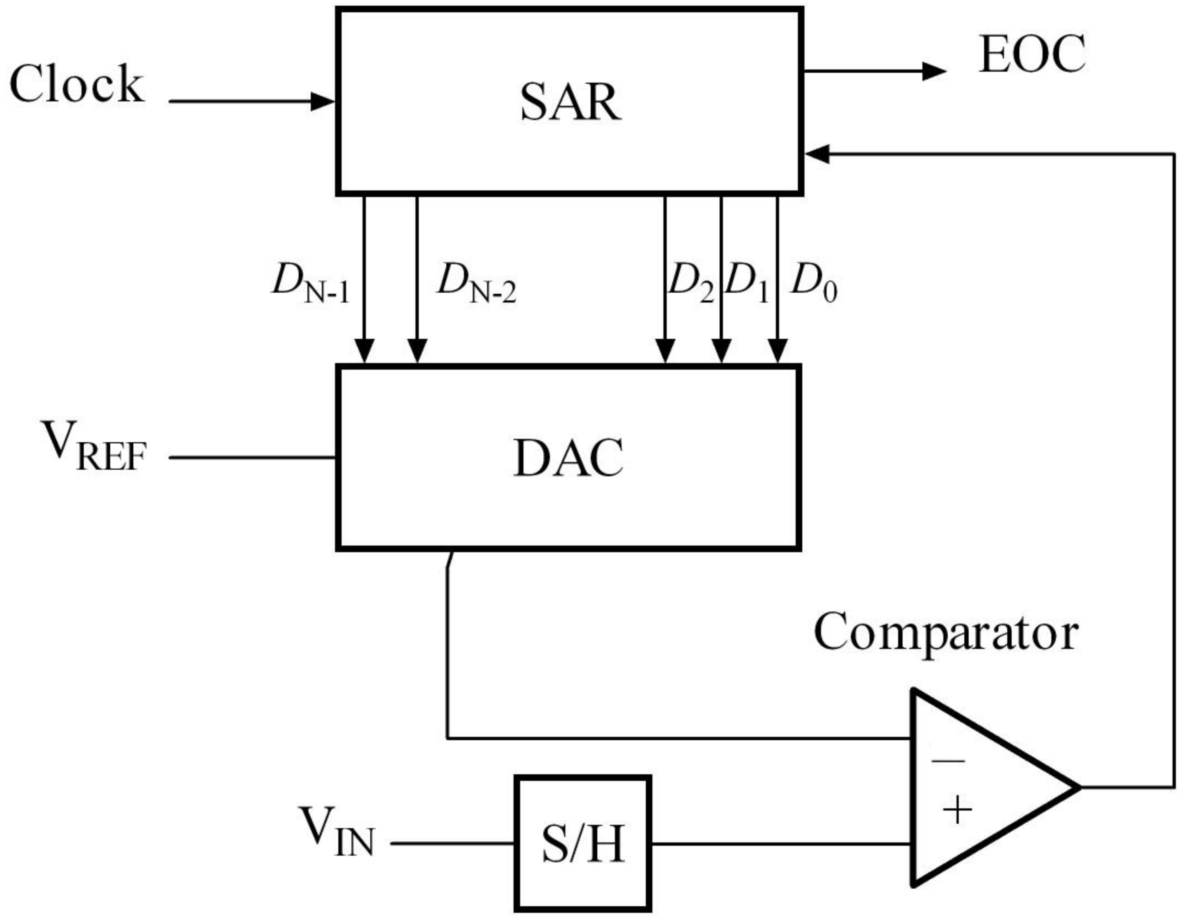
Project 1

4-bit Successive Approximation A to D Converter

Major elements:

- Sample/hold amplifier (S/H)
- D/A converter
- Comparator (Schmitt trigger recommended)
- Storage register
- Clock
- Control and sequencing logic

Project 1



Initial Specifications: Project #1

Create a 4-bit unipolar input SAR A/D converter which will

(1) Initiate a conversion sequence on command

(2) Present a digital parallel 4-bit conversion result (nibble) when data ready.

Initial Specifications: Project #1

3. Have an input range of 0-5 VDC.

4. Have a data conversion of at least 100 samples/second (sps). Conversion rate in excess of 1 ksps is desired.

5. No missing codes.

Initial Specifications: Project #1

(6) Have a unipolar power source or bipolar supply connections from bench power supply.
(7) Have an adequate associated test plan in which all tests pass.

Your design must not use any modern processors with the following exceptions:

- Act as control for your AD converter.
- to transfer data and display the result.

Anything that is part of the 4000-series CMOS family or equivalent is fair game. You have a budget of $100 for parts that cannot be found in the part store.

A few notes on A/D converters

- Convert an analog voltage into a digital representation
  - e.g., 2.45v → 0110
  - This conversion is dependent on the range of voltages to be converted and the number of bits used to represent the voltage

Notes on A/D Converters

Resolution: the smallest possible change that can be identified (resolved). Also called Least Significant Bit (LSB).

The term “LSB” or “counts” is used in several different ways. For example, a signal may have “five counts of noise.” This means the observed noise is equivalent to five times the value of the LSB.

Notes on A/D Converters

Bits of resolution	Number distinct values	Theoretical resolution
4	16	6.25%
8	256	0.39% = 3906 ppm
10	1024	977 ppm
12	4096	244 ppm
14	16384	61 ppm
16	65536	15 ppm
20	1048576	1 ppm

Notes on A/D Converters

Resolution and reference voltage are related, because sampled signal values are interpreted as a binary fraction of the reference voltage.

If $V_{ref} = 5.00\ V_{DC}$ and we are doing an 8-bit conversion,

Resolution = 5V/(256 values) = 19.5 mV/value

Notes on A/D Converters

If V_{ref} = 4.096 V_{DC} and we are doing a 12-bit conversion,
Resolution = 4.096V/(4096 values) = 1mV/value

The digitized signal value is equal to the number of counts (binary value) multiplied by the resolution. Any error from the original signal is called digitization noise.

Notes on A/D Converters