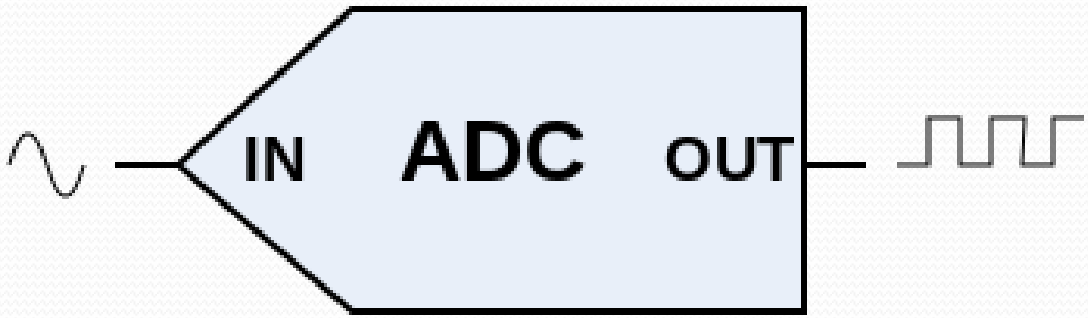
PIPELINED ADC

Area of Project :

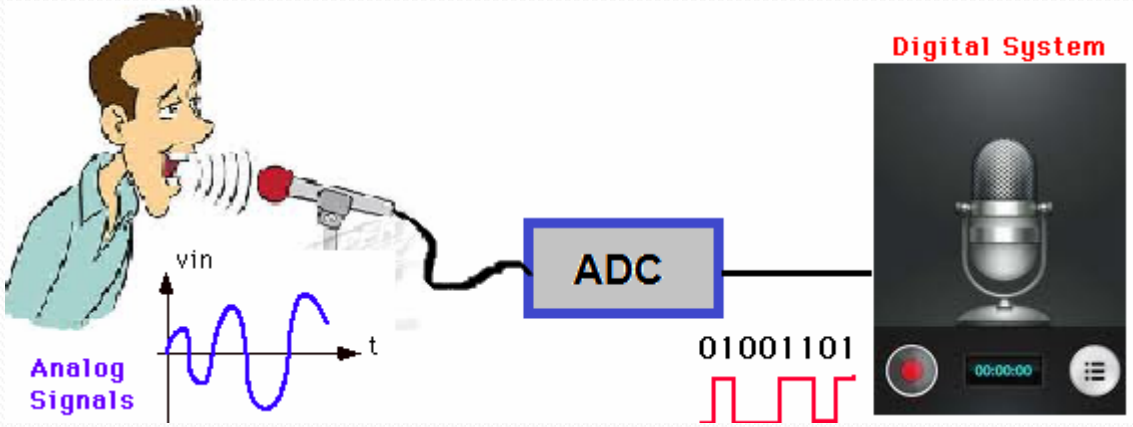
- Project work is in the area of Analog and VLSI Design focussing on data converters.
- Our project deals with ADC.



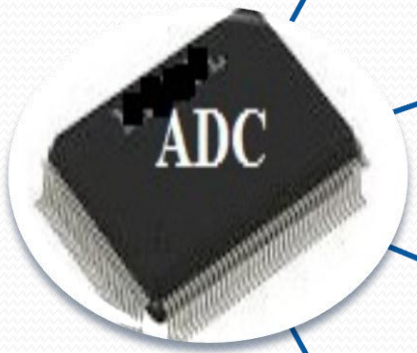
INTRODUCTION TO ADCs

ADC??

- Converts analog signals to digital signals.
- Used to establish an interface between analog and digital worlds.



Types of ADCs :



FLASH

- Fastest Architecture.
- Requires more hardware.

SUCCESS-IVE APPROXI-MATION

- High speed.
- But slower at higher resolutions.

SIGMA DELTA

- High resolution.
- Slow due to oversampling.

PIPELIN ED

- High speed.
- High accuracy.
- Low power consumption.

Comparison of various ADCs :

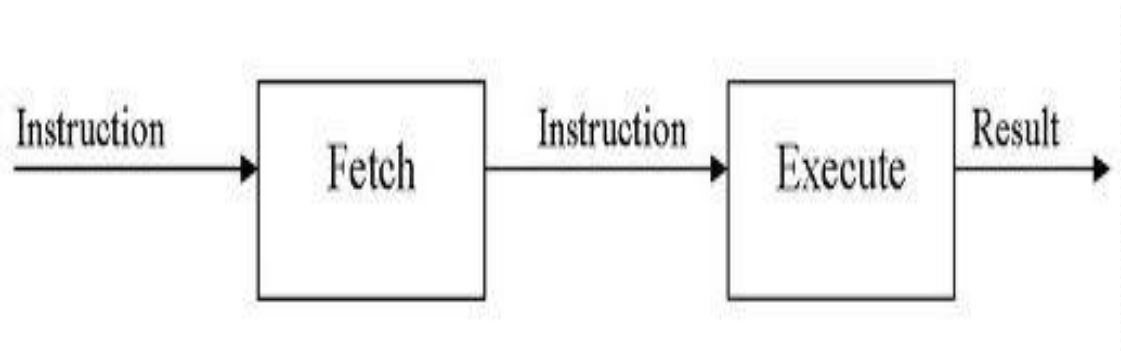
	FLASH ADC	SIGMA DELTA ADC	PIPELINED ADC
Resolution	Low	High	Moderate
Speed	High	Low	High

Objective of the project :

- This project aims at designing 10-bit Pipelined ADC with high speed (100MHz) and moderate (10 bit) resolution.

Introduction to pipelined ADC :

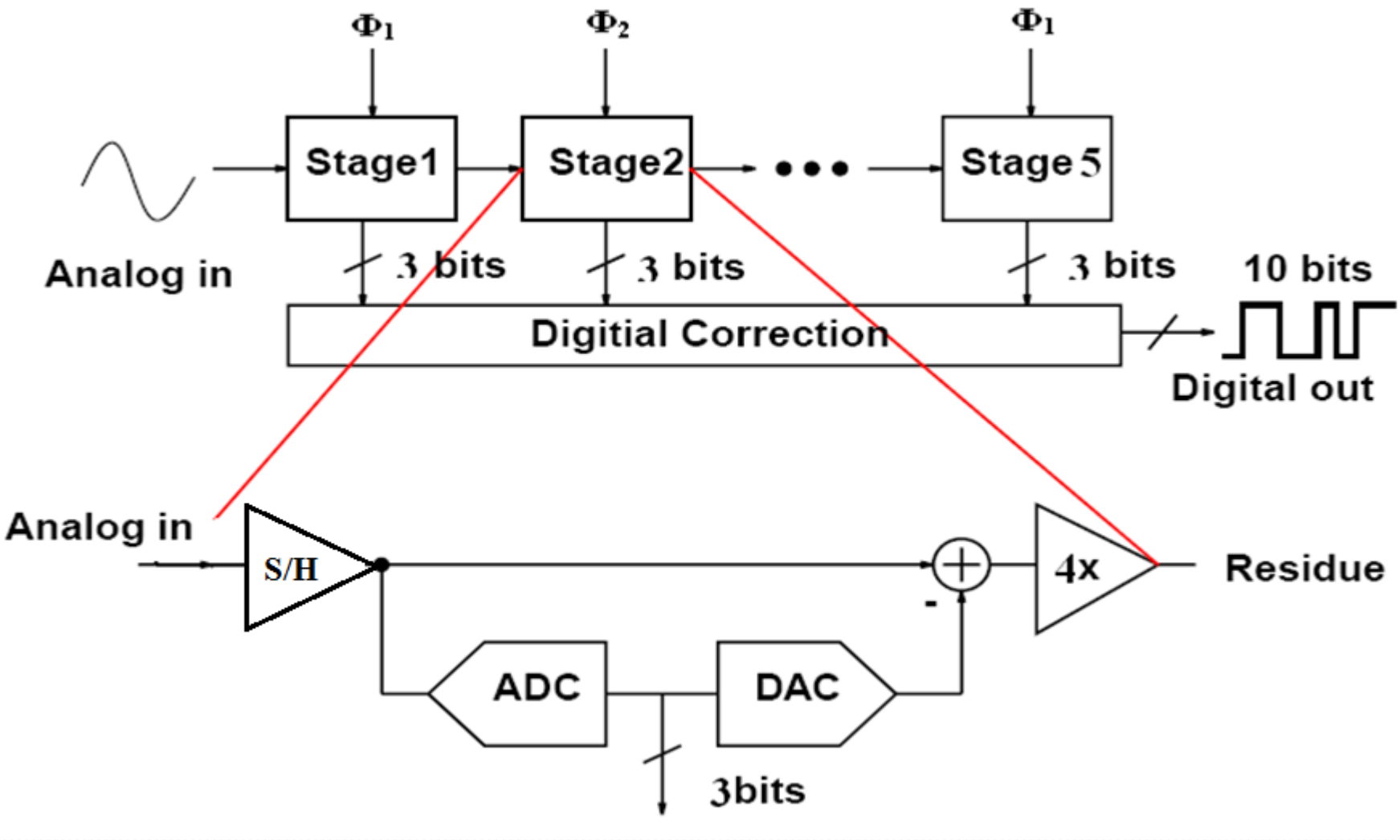
- The **Pipelined ADC** uses the concept of pipelining.
- Pipelining is a method of speeding up high volume processes.



Specifications :

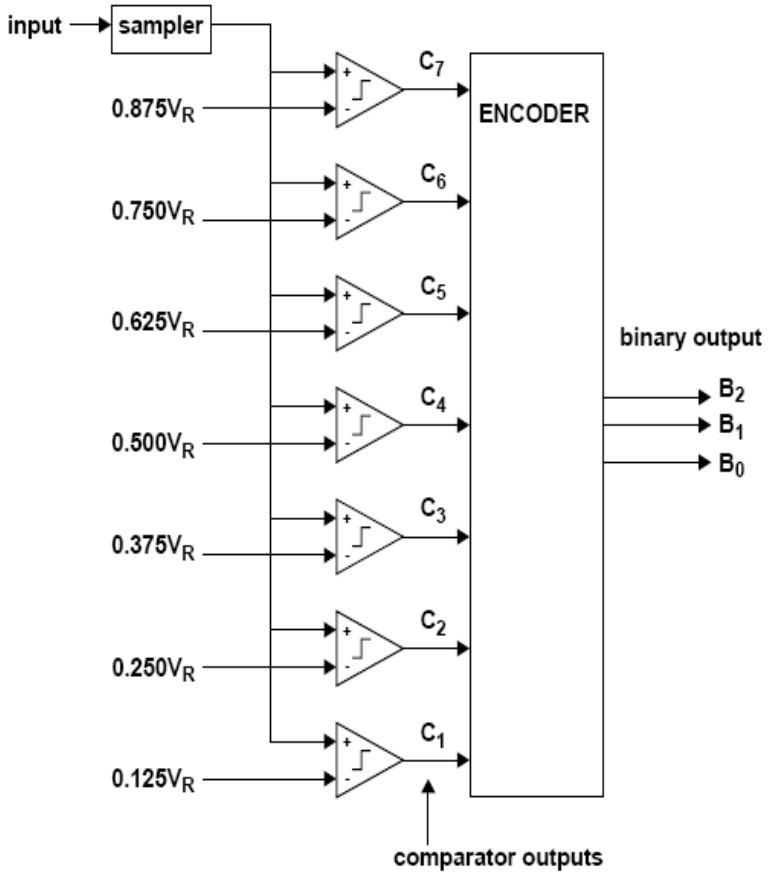
Stages	5
Resolution	10
No.of bits per staige	3
Sampling Frequency (f_s)	100 MHz

Block diagram of Pipelined ADC :



Sub-ADC (Flash) :

- Also known as a fully parallel architecture.
- An n-bit flash ADC consists of an array of 2^(n)-1 comparators and a set of 2^(n)- 1 reference values.
- The set of 2^(n)-1 comparator outputs that result is referred to as a thermometer code.
- The encoder converts the thermometer code produced by the comparators to a binary code as shown in the truth table .



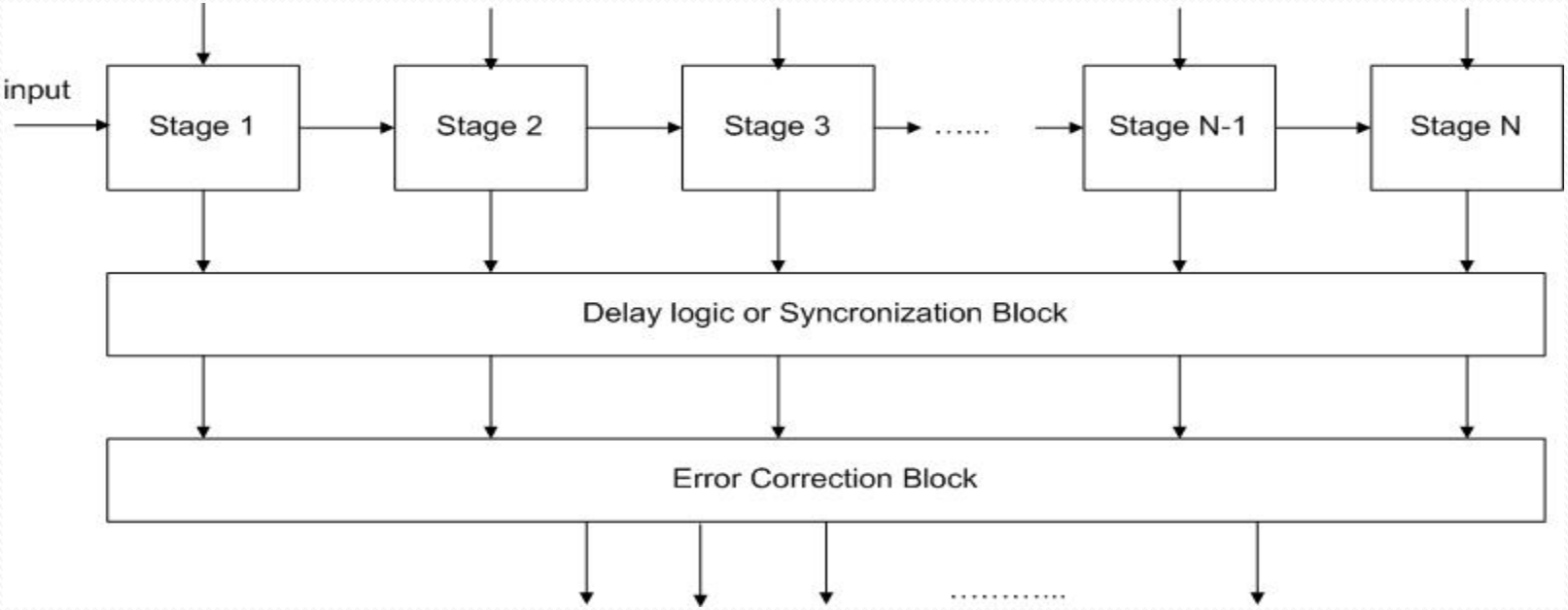
3-BIT FLASH ADC

Input/Output table of Flash ADC :

	C_7	C_6	C_5	C_4	C_3	C_2	C_1	B_2	B_1	B_0
$V_I < 0.125V_R$	0	0	0	0	0	0	0	0	0	0
$0.125V_R < V_I < 0.25V_R$	0	0	0	0	0	0	1	0	0	1
$0.25V_R < V_I < 0.375V_R$	0	0	0	0	0	1	1	0	1	0
$0.375V_R < V_I < 0.50V_R$	0	0	0	0	1	1	1	0	1	1
$0.50V_R < V_I < 0.625V_R$	0	0	0	1	1	1	1	1	0	0
$0.625V_R < V_I < 0.75V_R$	0	0	1	1	1	1	1	1	0	1
$0.75V_R < V_I < 0.875V_R$	0	1	1	1	1	1	1	1	1	0
$V_I > 0.875V_R$	1	1	1	1	1	1	1	1	1	1

Digital Correction Logic :

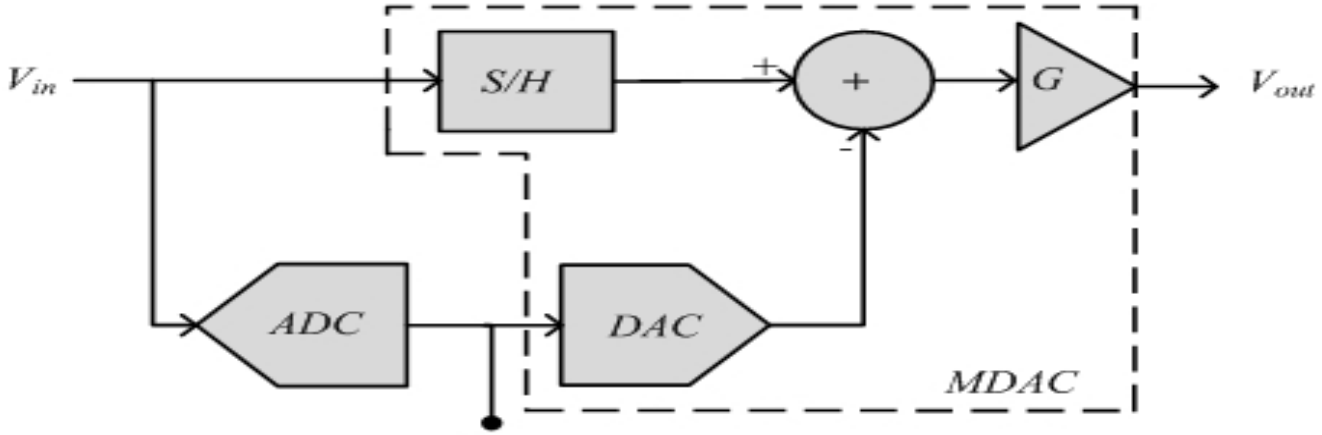
- Consists of shift registers for time alignment.
- It corrects the over ranging problems due to offset and interstage amplifier errors.



Multiplying DAC :

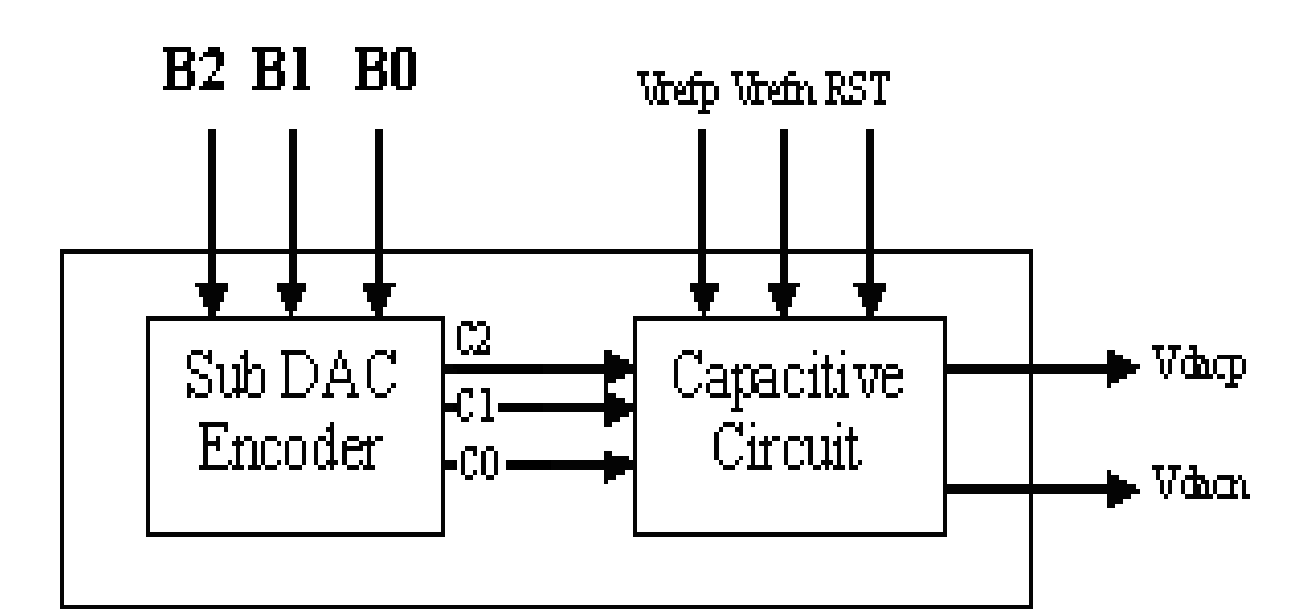
The function of this circuit is threefold:

- To sample and hold the input signal.
- To generate a residue that is the difference between the input and sub-DAC output.
- To amplify this residue.



Sub-DAC :

- Converts the intermediate digital outputs available at every stage into its equivalent analog output.



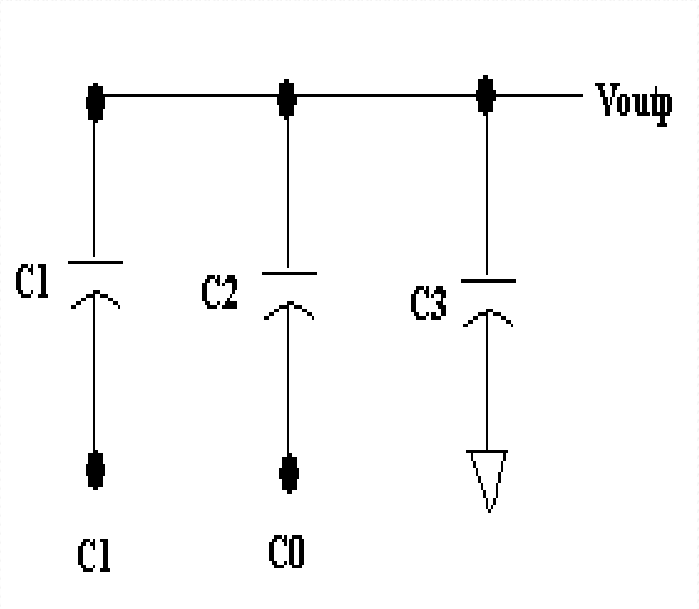
Block Diagram of Sub-DAC

- Inputs for the Sub DAC are the output of Sub ADC (B2, B1, Bo), reference voltage (V_{ref}).
- Encoder is used to encode the outputs of the sub-ADC output into the required sequence.

Actual DAC Input B2 B1 B0	Encoded Sequence C2 C1 C0	DAC Output
1 1 0	1 1 1	Vr
1 0 1	1 1 0	2Vr/3
1 0 0	1 0 1	Vr/3
0 1 1	0 0 0	0
0 1 0	0 0 1	-Vr/3
0 0 1	0 1 0	-2Vr/3
0 0 0	0 1 1	-Vr

Input/output Table of Sub-DAC

- To get the required DAC output for the encoded sequence, a capacitive circuit is used.
- It consists of 3 capacitors as shown fig C1, C2 and C3 of values 2C, C and 3C respectively.
- Two LSB bits C1 and C0 are the inputs for the two capacitances and the MSB bit C2 is used for the sign.



Example:

- If C1=0 and C0=0 then the output is 0, because the capacitors are not charged.
- If C1=0 and C0=1 then

$$Voutp = \frac{C2}{C1 + C2 + C3} = \frac{C}{6C} = \frac{1}{6} Vref$$

Similarly,

$$Voutn = -\frac{1}{6} Vref$$

It implies

$$Vout = Voutp - Voutn = \frac{1}{3} Vref$$

Operational Transconductance Amplifier :

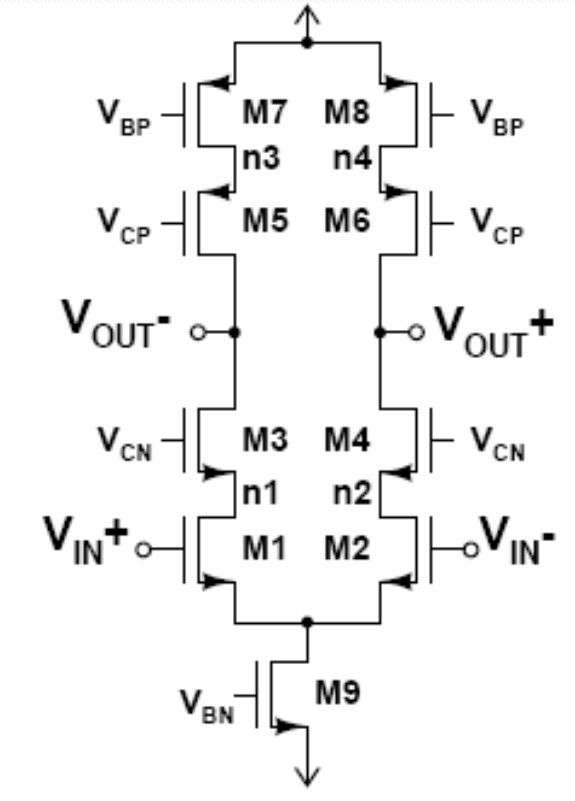
- It is an operational amplifier with high input and output resistance.
- It operates at high frequencies.

Types of OTAs :

- Telescopic OTA
- Folded Cascode OTA
- Gain Boosted OTA

Telescopic OTA :

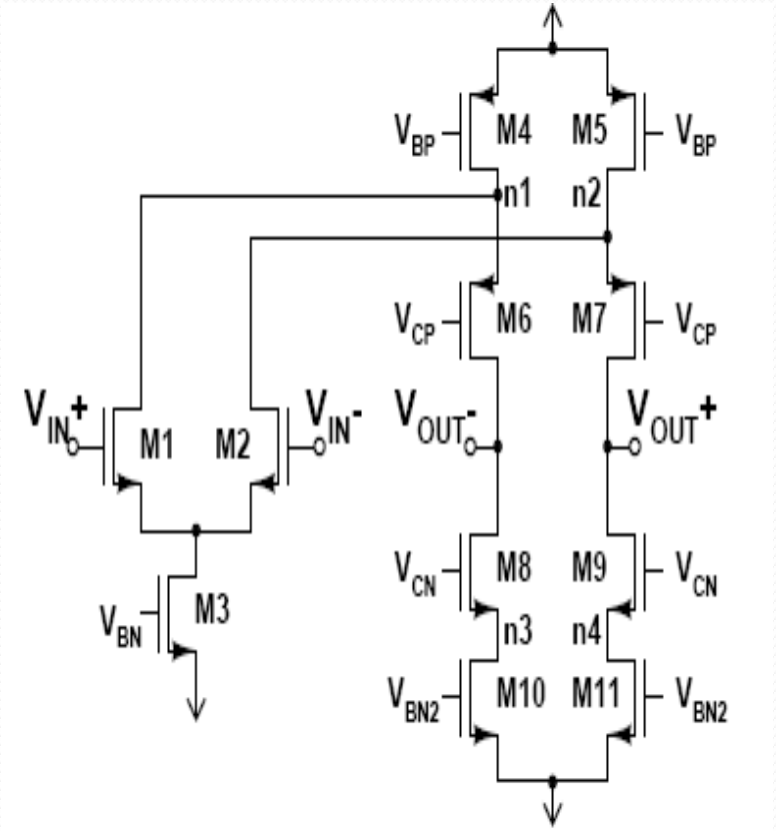
- Fastest possible architecture.
- High voltage gain.
- Large bandwidth.
- Good phase margin.
- Low power consumption.
- Low output swing.



Telescopic OTA.

Folded cascode OTA:

- They are of two types namely-
  - Folded cascode top
  - Folded cascode bottom
- Used as auxiliary amplifier.
- Commonly used op-amp architecture .
- Provides a larger output swing.
- Lower voltage gain than that of Telescopic OTA.
- More power dissipation.



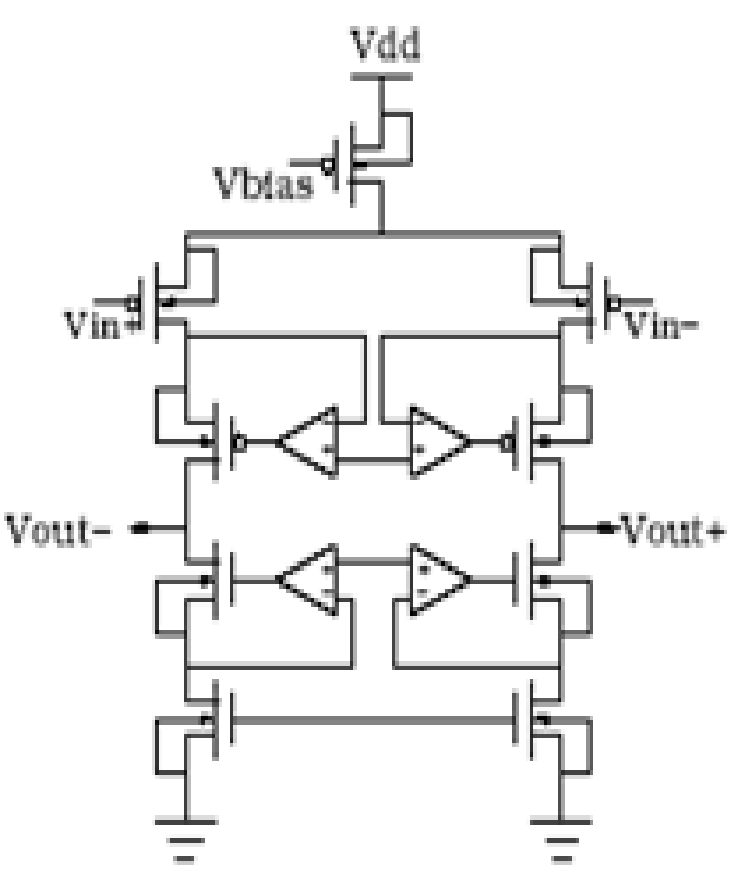
High gain

High output swing

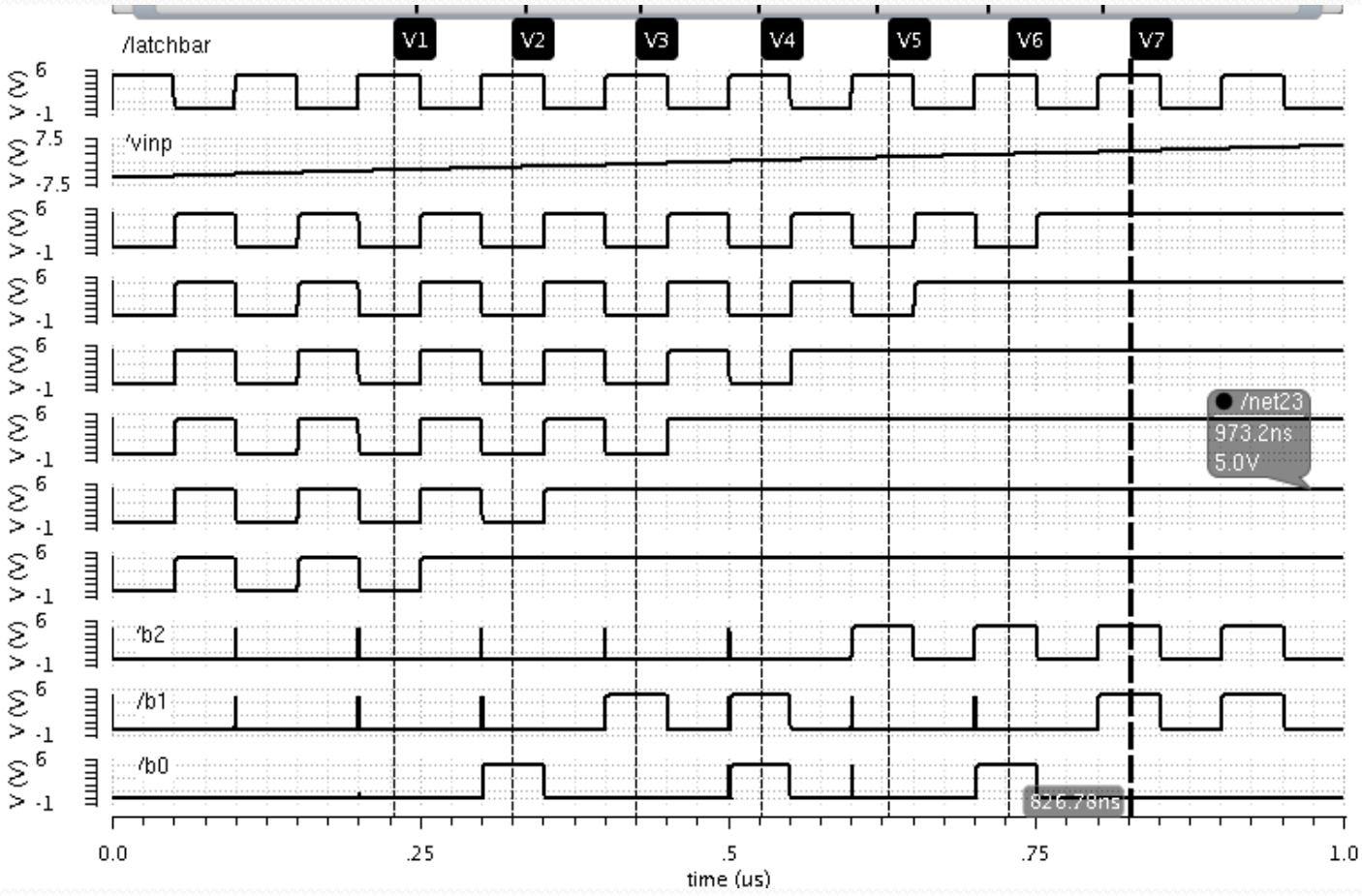
High gain and high output swing

Gain Boosted Op-amp:

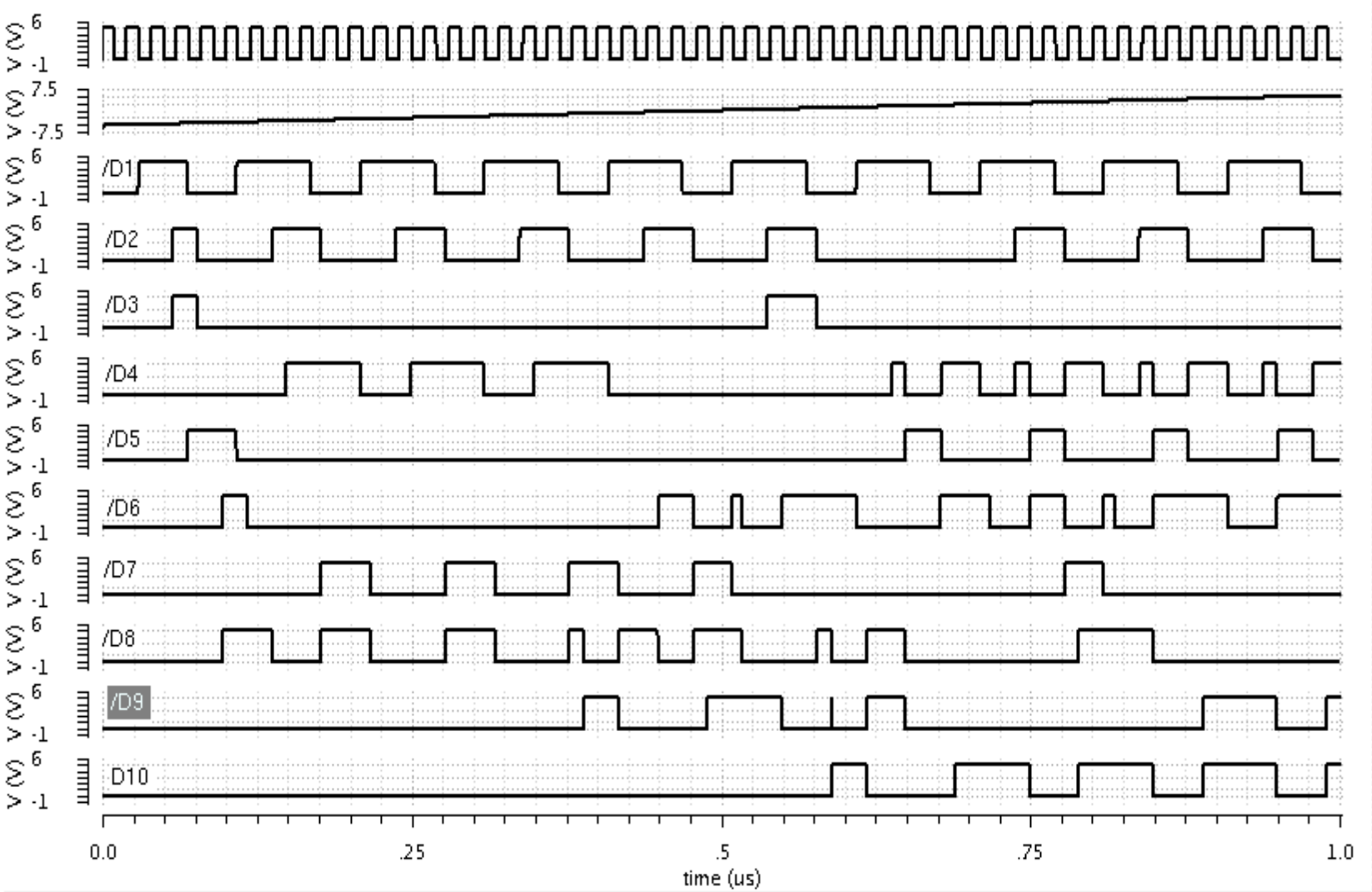
- The two folded cascode auxiliary amplifiers and the telescopic amplifier are integrated together to form the gain boosted OTA.
- The outputs of two folded cascode OTA are connected to the telescopic OTA to provide the bias and the required gain boosting.
- Higher speed operation.
- Higher power efficiency and lower noise factor.



Simulation Results :



Response of sub-ADC to a ramp input



Digital output of 10-bit pipelined ADC for a ramp input

Applications:

- The commonly used applications of Pipeline ADCs are high quality video systems, Radio base stations and high performance digital communication system etc.
- Applications of pipelined ADC based on its resolution are:

Resolution	Applications
8	➢ Lab instrumentation ➢ Medical Imaging ➢Radar
10	➢ Flat Panel Displays ➢ CCD imaging
14	➢ Military ➢ Aerospace

References:

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