10 bit potentiometric DAC 3.3v Analog voltage, 1.8v digital voltage and 1 off-chip external voltage reference

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Abstract— This paper discusses the basics of Potentiometric Digital to Analog converter with an off-chip external voltage reference, 3.3 V analog voltage and 1.8 V digital voltage.

Keywords—DAC, RDAC, potentiometer, off-chip, resolution, INL, resistor-string, voltage-scaling, CMOS, transmission gate, Inverter, DNL, Offset, CMOS, Voltage Scaling, DAC Stages

I. INTRODUCTION

Today with the rapid advances in electronic technology, most of the microelectronics systems are digital in nature. The power consumption for the digital systems is lower and also they are noise- immune. So, it is preferred to store and transmit data through digital systems. But in the real world most of the data is still analogous in nature. So, there is requirement of a system to convert digital signals to analog and vice-versa. A DAC (Digital to analog converter) is a circuit which is used to convert digital signals to analog signals with respect to an external reference voltage. An N-bit DAC takes an input of N-bits and converts the signal into an analog output in the form of voltage or current [5]. A DAC converts the digital signal into analog by reconstructing sampled data. The digital data may be produced from a microprocessor, Application Specific Integrated Circuit (ASIC), FPGA (field programmable gate array) [6] and is converted into analog form.

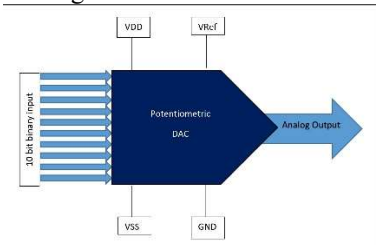

Fig. 1.Block Diagram of DAC

II. DAC TYPES AND WORKING

The various DAC topologies are such as interpolating, binary weighted, multiplying, R-2R ladder, successive approximation thermometer-coded, and hybrid type DAC topologies .Digital potentiometer or RDAC or potentiometric DAC or Voltage Scaling DAC is like a variable resistor which is controlled by digital signals instead of by mechanical movements. It includes mosfet switches to electrically connect a string of n resistors between two voltage supplies [2]. Resolution of a DAC is the number of bits in the digital input or the step size. A 10-bit potentiometric DAC has 1024 steps and its resolution is 10-bits. More is the number of bits, better is the reconstruction of the analog signal from the digital input. For a Voltage Scaling DAC, the no of resistors required is 2^n.This amounts to 1024 resistors for a 10 bit DAC. So, we implement the DAC in stages. For a 2 stage DAC, each stage needs $2^{n/2}$ resistors, thus reducing the no of resistors to 64.

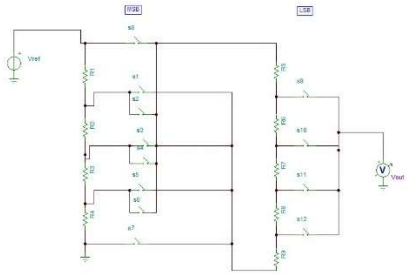

Fig. 2. Two-Stage Potentiometric DAC [1]

III. DAC PARAMETERS

The various factors to be considered while designing a DAC are offset error, full-scale error, gain error, INL (integral non linearity error), DNL (Differential non linearity error), and TUE (Total unadjusted error).DNL measures the worst case deviation of any two sequential codes across the DAC transfer function.

$DNL = \text{mod}\ ([(V_{D+1} - V_D)/V_{LSB\text{-}IDEAL} - 1])$ [4]

INL is used for measuring relative accuracy of the output by measuring the deviation of the code form the ideal transfer function [4].

$INL = \text{mod}\ ([(V_D - V_{ZERO})/V_{LSB\text{-}IDEAL}] - D)$ [4]

IV. APPLICATIONS

DAC's play an important role in the electronics industry. Parameters like offset, gain, current are adjusted based on different applications. Different applications of DAC's include audio conversion, video processing, digital radio, motor control, calibration, data distribution systems, signal processors, etc. The major advantages of potentiometric DAC are better setability, immunity to mechanical vibrations and oxidation of viper contacts, etc.

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