ELL100 LAB PROJECT

Digital to Analog Converter

**Submitted by,**

LOKESH PATEL 2017ME10584

ANCHIT TANDON 2017MT60772

**Objective:**

Study of digital to Analog converter using R–2R ladder circuit.

**Equipment:**

1. Breadboard.
2. OpAmp 741
3. Resistors
4. Wires

**Theory**

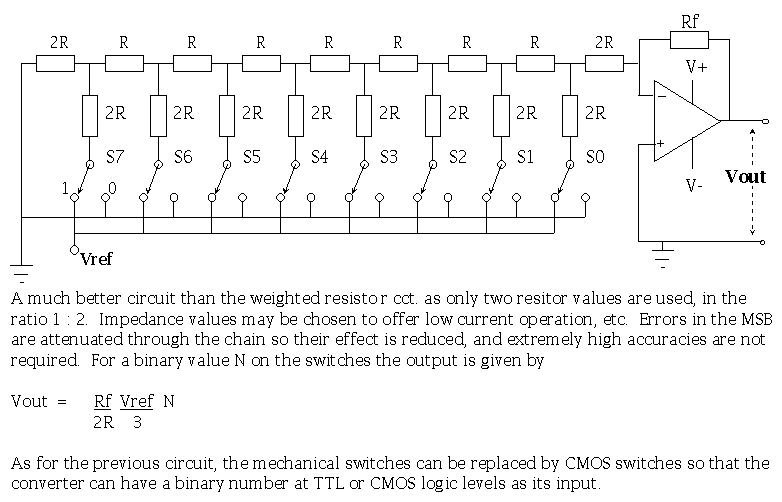
Real world signals are analog. Digital systems that interface with the real world do so using analog-to-digital converters (ADC). Conversion back to analog is accomplished using digital-to-analog converters (DAC). The R-2R ladder network is commonly used for Digital to Analog conversions.

In basic N-bit R-2R resistor ladder network the digital inputs or bits range from the most significant bit (MSB) to the least significant bit (LSB). The bits are switched between either 0V or VR and depending on the state and location of the bits Vo will vary between 0V and VR. The MSB causes the greatest change in output voltage and the LSB causes the smallest.

The R-2R ladder is inexpensive and relatively easy to manufacture since only two resistor values are required. It is fast and has fixed output impedance R.

In R-2R ladder type D to A converter, only two values of resistor are used (i.e. R and 2R). Hence it is suitable for integrated circuit fabrication. The typical values of R are from 2.5KΩ to 10KΩ. In this output voltage is a weighted sum of digital inputs. Since the resistive ladder is a linear network, the principle of superposition can be used to find the total analog output voltage for a particular digital input by adding the output voltages caused by the individual digital inputs. The output voltage is linearly proportional to the digital input, and the range can be adjusted by changing the reference voltage VR.

**Circuit Diagram**

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**Observations**

|  |  |
| --- | --- |
| Digital Input | Analog Output |
| 0 0 0 0 0 0 0 1 |  |
| 0 0 0 0 0 0 1 0 |  |
| 0 0 0 0 0 1 0 0 |  |
| 0 0 0 0 1 0 0 0 |  |
| 0 0 0 1 0 0 0 0 |  |
| 0 0 1 0 0 0 0 0 |  |
| 0 1 0 0 0 0 0 0 |  |
| 1 0 0 0 0 0 0 0 |  |

**Conclusion**

This method improves the precision due to the relative ease of producing equal valued-matched resistors (or current sources).

**Applications of Digital to Analog Converter**

DACs are used in many digital signal processing applications and many more applications. Some of the important applications are discussed below.

*Audio Amplifier:*

DACs are used to produce DC voltage gain with Microcontroller commands. Often, the DAC will be incorporated into an entire audio codec which includes signal processing features.

*Video Encoder:*

The video encoder system will process a video signal and send digital signals to a variety of DACs to produce analog video signals of various formats, along with optimising of output levels. As with audio codecs, these ICs may have integrated DACs.

*Display Electronics:*

The graphics controller will typically use a lookup table to generate data signals sent to a video DAC for analog outputs such as Red, Green, Blue (RGB) signals to drive a display.

*Data Acquisition Systems:*

Data to be measured is digitised by an Analog-to-Digital Converter (ADC) and then sent to a processor. The data acquisition will also include a process control end, in which the processor sends feedback data to a DAC for converting to analog signals.

*Calibration:*

The DAC provides dynamic calibration for gain and voltage offset for accuracy in test and measurement systems.

*Motor Control:*

Many motor controls require voltage control signals, and a DAC is ideal for this application which may be driven by a processor or controller.

*Data Distribution System:*

Many industrial and factory lines require multiple programmable voltage sources, and this can be generated by a bank of DACs that are multiplexed. The use of a DAC allows the dynamic change of voltages during operation of a system.

*Digital Potentiometer:*

Almost all [digital potentiometers](https://www.elprocus.com/types-of-variable-resistors-its-working-and-applications/) are based on the string DAC architecture. With some reorganisation of the resistor/switch array, and the addition of [an I2C compatible interface](https://www.elprocus.com/i2c-bus-protocol-tutorial-interface-applications/), a fully digital potentiometer can be implemented.