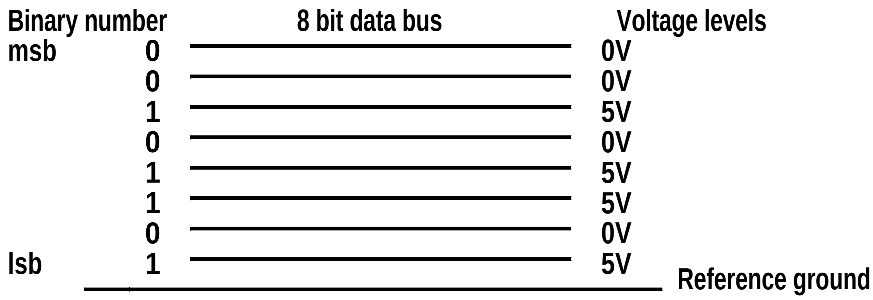
In a digital to analog converter or DA converter:—

- A resistive ladder is used to give successive fractions of a reference voltage.

- Each divided down voltage fraction drives a current, proportional to the voltage, through a resistor.

- The current through the resistors can be switched to the input of a current to voltage converter.

- The current to voltage converter sums all of the switched currents to generate a voltage output proportional to the binary value of the switches.

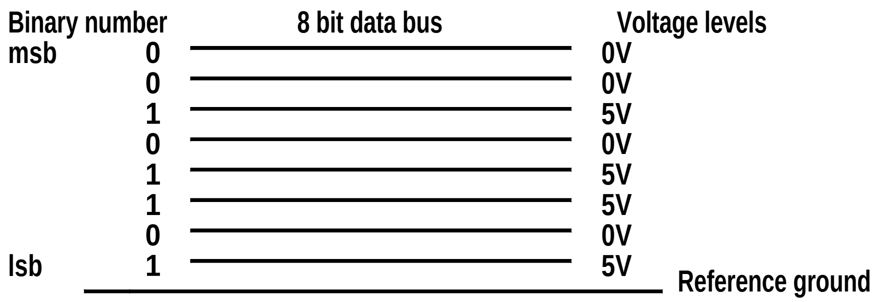


Analog electronics—continuously variable quantities
Represent continuous real world variables

Digital electronics—Binary numbers
Represented by discrete voltage levels.

Need Digital to Analog conversion

and Analog to Digital conversion.



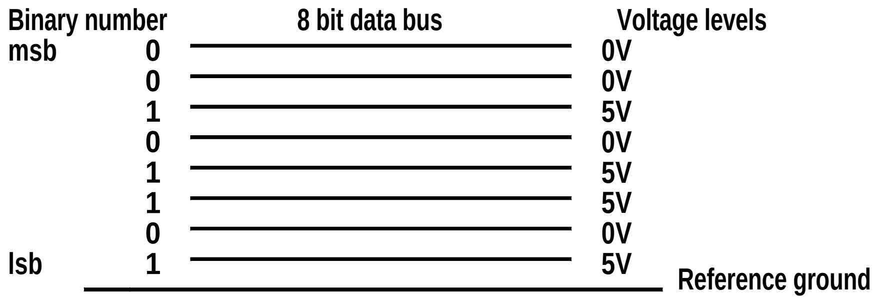
Binary number and corresponding voltage levels on the bus
Position used to represent the significance of the number

$$00101101_{Binary}$$

$$= 1\times2^5+0\times2^4+1\times2^3+1\times2^2+0\times2^1+1\times2^0$$

$$= 45_{Decimal}$$

A bus of 8 wires in parallel
A $0V$ on the wire represents a logical 0
A $5V$ on the wire represents a logical 1

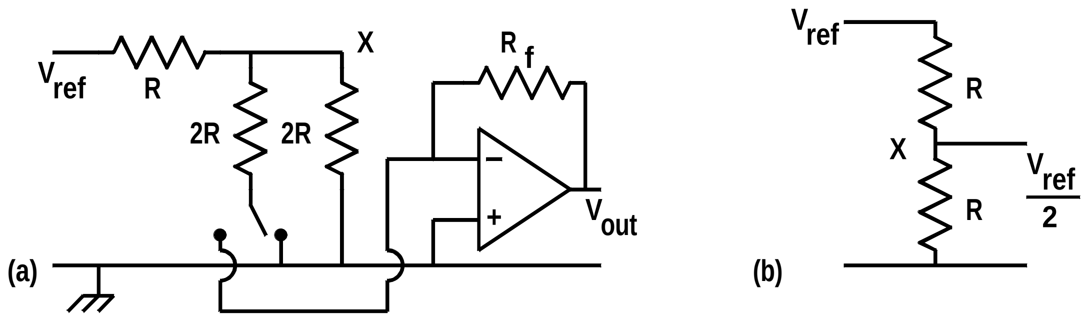


8, 12, 14 and 16 bit data buses are used.

Set range of the output.
Range 00000000 to 11111111 in binary corresponds to 0 to 255 in decimal.
Instead of $0V$ to $1V$ we generate a set of 256 discrete values spaced at intervals of $\frac{1}{256} = 3.9mV$ apart.
The resolution is $3.9mV$.

The problem of D to A conversion has now been reduced to:—

Given 8 wires going into a converter circuit, with voltage levels on these wires representing an 8 bit binary number, how can a voltage be generated at the output of the DA converter which is proportional to this binary number?

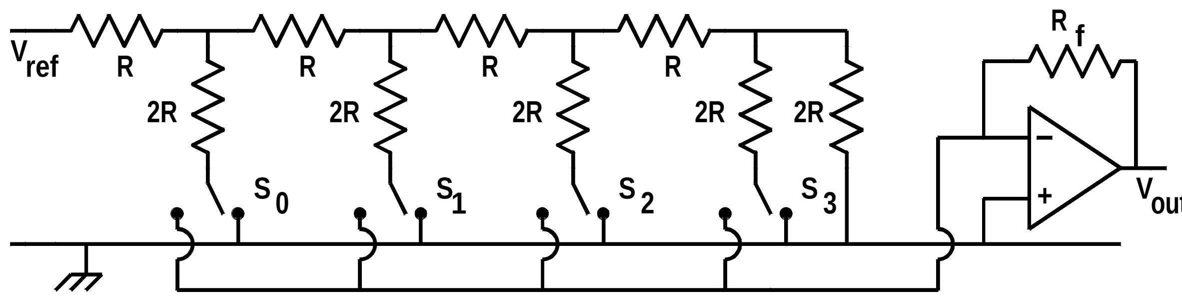


Most commonly used system is called the $R-2R$ ladder converter.

$$V_{out} = -\frac{V_{ref}}{2 \times 2R} R_f \quad \text{or} \quad 0$$

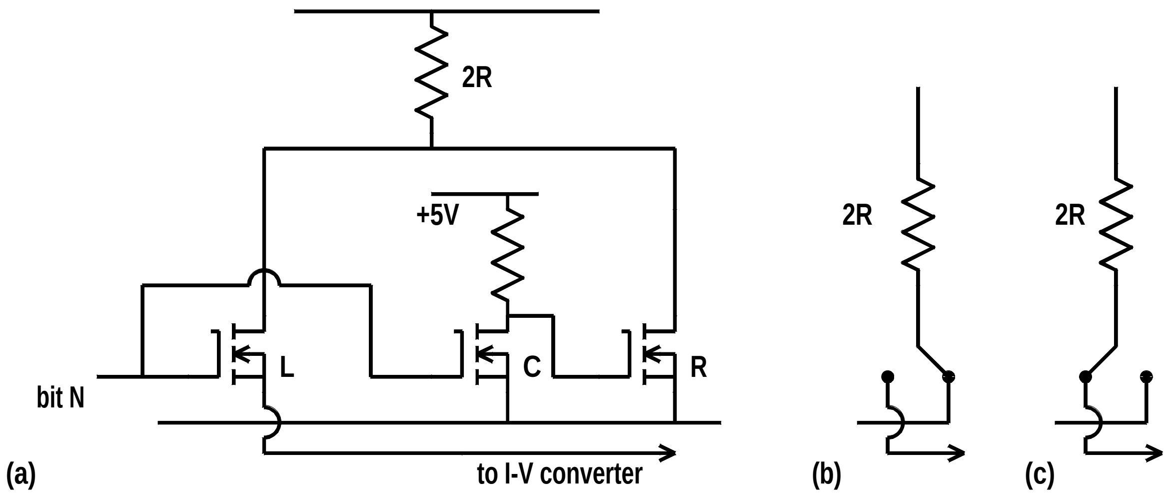
depending on the position of the switch.

Also a current to voltage converter



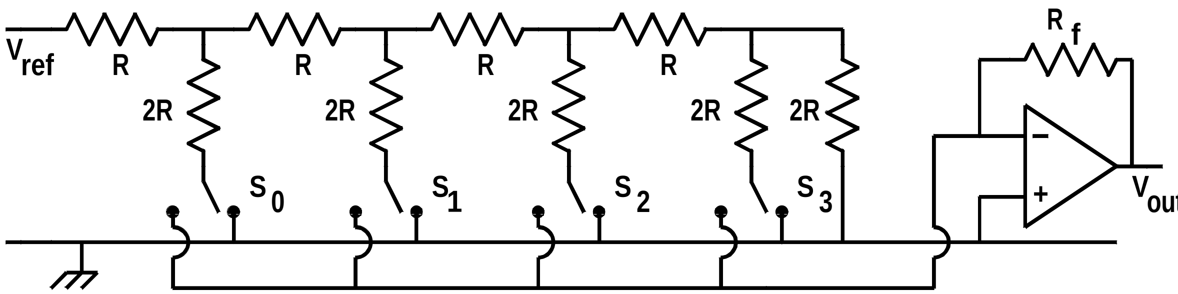
$R - 2R$ Ladder network.

The voltage at the equivalent of point X in the elemental ladder is reduced by a factor of 2 as we progress from left to right along the ladder.



FET switches are used with $R - 2R$ ladder network.

Enhancement type MOSFETS.



The current to voltage circuit sums all of the currents through the $2R$ resistors from each of the voltage tap off points on the $R - 2R$ ladder and gives an output voltage

$$V_{out} = -R_f \frac{V_{ref}}{4R} \left(S_0 + \frac{S_1}{2} + \frac{S_2}{4} + \frac{S_3}{8} + \ldots \right)$$

where S_N is the digital state of the relevant line on the data bus and takes the value 0 or 1.

The advantages of this $R-2R$ ladder network are that

- Only two values of resistors (or one value if two are used in series) are required to be fabricated on the silicon chip.
- Typical values are $10k\Omega$.
- The fabrication can be carried out to the required precision if only one value is required.
- The resistors do not have to be precise values. They only need to be equal valued.