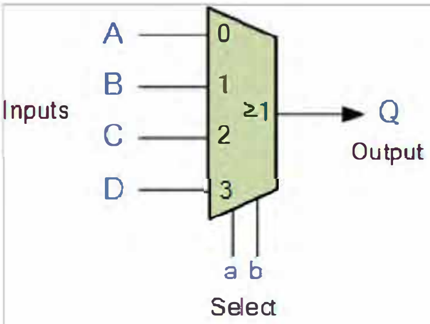


The Multiplexer

The multiplexer is a combinational logic circuit designed to switch one of several input lines to a single common output line

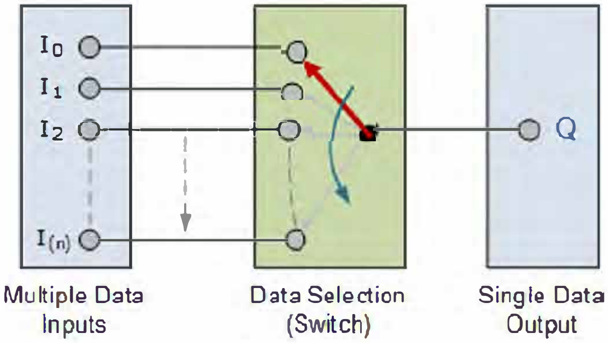
Multiplexing is the generic term used to describe the operation of sending one or more analogue or digital signals over a common transmission line at different times or speeds and as such, the device we use to do just that is called the multiplexer.

The *multiplexer*, shortened to "MUX" or "MPX", is a combinational logic circuit designed to switch one of several input lines through to a single common output line by the application of a control signal. Multiplexers operate like very fast acting multiple position rotary switches connecting or controlling multiple input lines called "channels" one at a time to the output.

Multiplexers, or MUX's, can be either digital circuits made from high speed logic gates used to switch digital or binary data or they can be analogue types using transistors, MOSFET's or relays to switch one of the voltage or current inputs through to a single output.

The most basic type of multiplexer device is that of a one-way rotary switch as shown.

Basic Multiplexing Switch



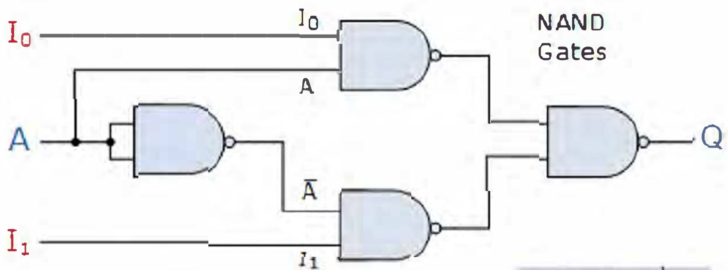
The rotary switch, also called a wafer switch as each layer of the switch is known as a wafer, is a mechanical device whose input is selected by rotating a shaft. In other words, the rotary switch is a manual switch that you can use to select individual

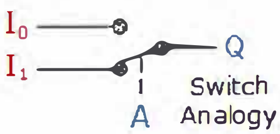
Generally, the selection of each input line in a multiplexer is controlled by an additional set of inputs called *control lines* and according to the binary condition of these control inputs, either "HIGH" or "LOW" the appropriate data input is connected directly to the output. Normally, a multiplexer has an even number of 2^n data input lines and a number of "control" inputs that correspond with the number of data inputs.

Note that multiplexers are different in operation to *Encoders*. Encoders are able to switch an n-bit input pattern to multiple output lines that represent the binary coded (BCD) output equivalent of the active input.

We can build a simple 2-line to 1-line (2-to-1) multiplexer from basic logic NAND gates as shown.

2-input Multiplexer Design





Truth Table

Inputs			
A	I_1	I_0	Q
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	0
1	1	1	1

The input A of this simple 2-1 line multiplexer circuit constructed from standard NAND gates acts to control which input (I_0 or I_1) gets passed to the output at Q.

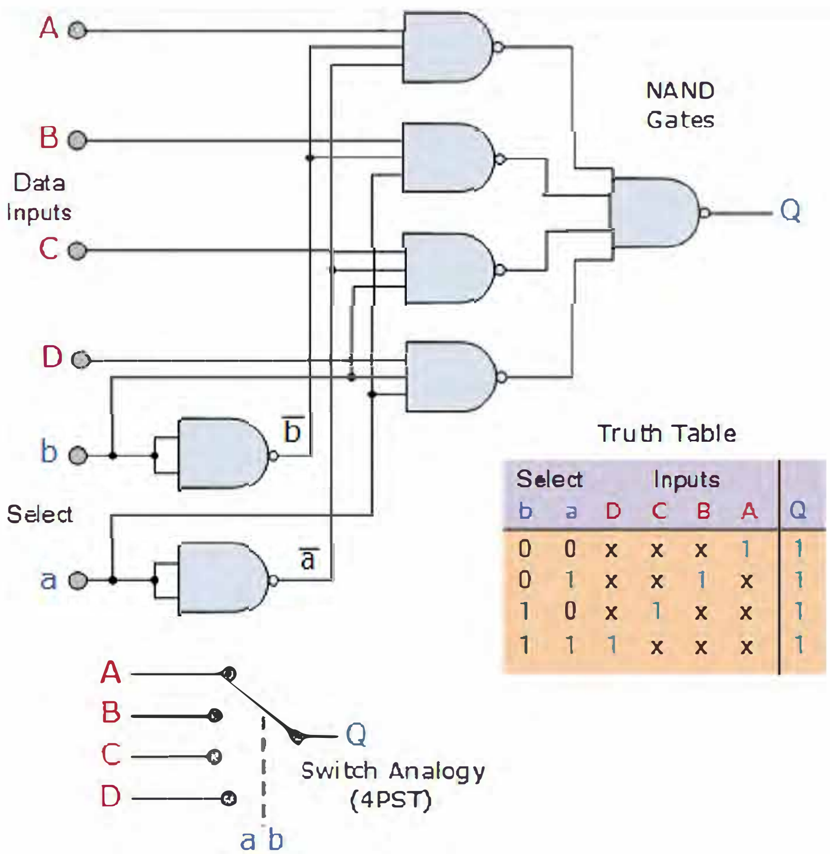
From the truth table above, we can see that when the data select input, A is LOW at logic 0, input I_1 passes its data through the NAND gate multiplexer circuit to the output, while input I_0 is blocked. When the data select A is HIGH at logic 1, the reverse happens and now input I_0 passes data to the output Q while input I_1 is blocked.

So by the application of either a logic "0" or a logic "1" at A we can select the appropriate input, I_0 or I_1 with the circuit acting a bit like a single pole double throw (SPDT) switch.

As we only have one control line, (A) then we can only switch 2^1 inputs and in this simple example, the 2-input multiplexer connects one of two 1-bit sources to a common output, producing a 2-to-1-line multiplexer. We can confirm this in the following Boolean expression.

$$Q = \overline{A}.\overline{I_0}.I_1 + \overline{A}.I_0.I_1 + A.I_0.\overline{I_1} + A.I_0.I_1$$

and for our 2-input multiplexer circuit above, this can be simplified too:



Select		Inputs				Q
b	a	D	C	B	A	Q
0	0	x	x	x	1	1
0	1	x	x	1	x	1
1	0	x	1	x	x	1
1	1	1	x	x	x	1

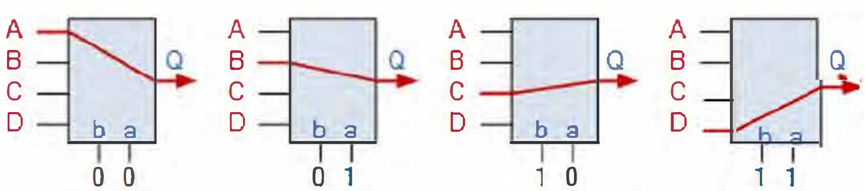
The Boolean expression for this 4-to-1 **Multiplexer** above with inputs A to D and data select lines a, b is given as:

$Q = \bar{a}\bar{b}A + a\bar{b}B + \bar{a}bC + abD$

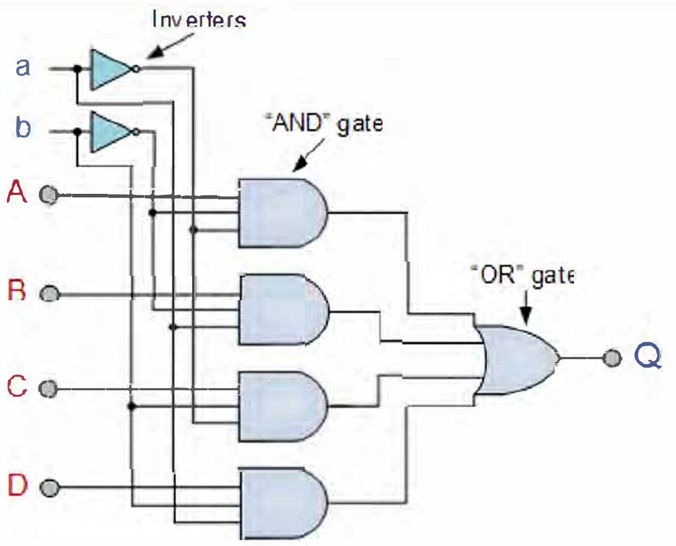
In this example at any one instant in time only ONE of the four analogue switches is closed, connecting only one of the input lines A to D to the single output at Q. As to which switch is closed depends upon the addressing input code on lines "a" and "b".

So for this example to select input B to the output at Q, the binary input address would need to be "a" = logic "1" and "b" = logic "0". Thus we can show the selection of the data through the multiplexer as a function of the data select bits as shown.

Multiplexer Input Line Selection

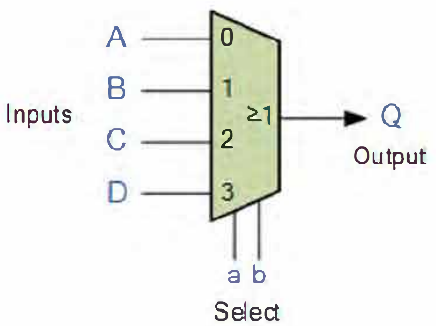


Adding more control address lines, (n) will allow the multiplexer to control more inputs as it can switch 2^n inputs but each



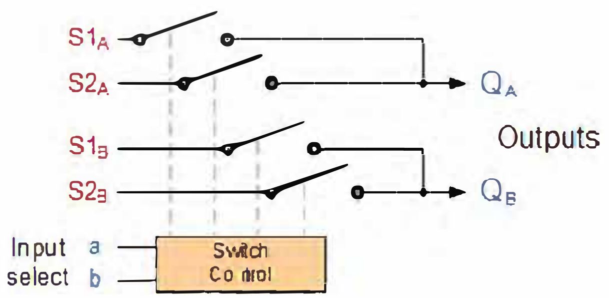
The symbol used in logic diagrams to identify a multiplexer is as follows:

Multiplexer Symbol

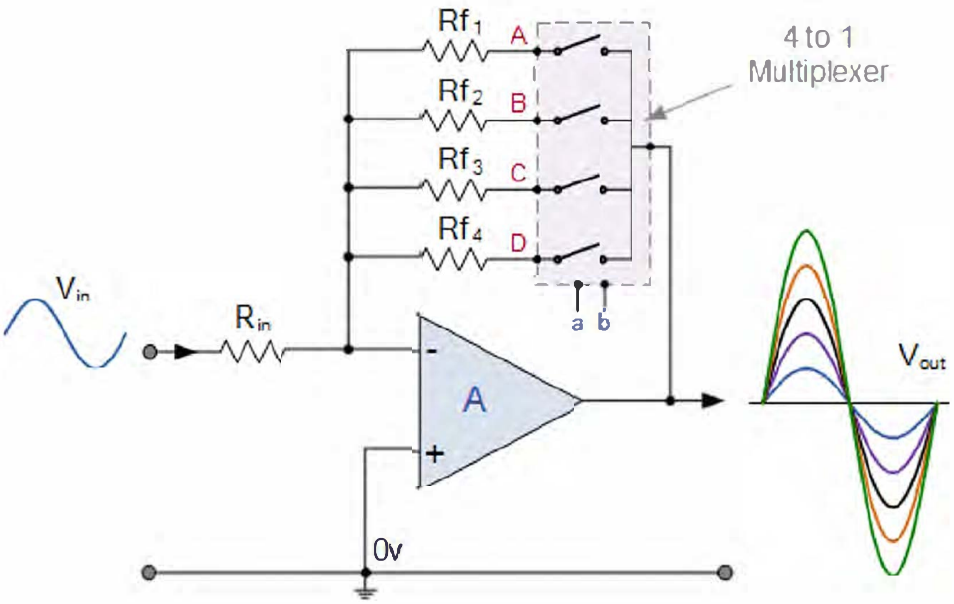


Multiplexers are not limited to just switching a number of different input lines or channels to one common single output. There are also types that can switch their inputs to multiple outputs and have arrangements or 4-to-2, 8-to-3 or even 16-to-4 etc configurations and an example of a simple Dual channel 4 input multiplexer (4-to-2) is given below:

4-to-2 Channel Multiplexer



Digitally Adjustable Amplifier Gain



Here, the voltage gain of the inverting operational amplifier is dependent upon the ratio between the input resistor, R_{IN} and its feedback resistor, Rf as determined in the Op-amp tutorials.

A single 4-channel (Quad) SPST switch configured as a 4-to-1 channel multiplexer is connected in series with the resistors to select any feedback resistor to vary the value of Rf. The combination of these resistors will determine the overall voltage gain of the amplifier, (Av). Then the voltage gain of the amplifier can be adjusted digitally by simply selecting the appropriate resistor combination.

Digital multiplexers are sometimes also referred to as "Data Selectors" as they select the data to be sent to the output line and are commonly used in communications or high speed network switching circuits such as LAN´s and Ethernet applications.

Some multiplexer IC´s have a single inverting buffer (NOT Gate) connected to the output to give a positive logic output (logic "1", HIGH) on one terminal and a complimentary negative logic output (logic "0", LOW) on another different terminal.

It is possible to make simple multiplexer circuits from standard AND and OR gates as we have seen above, but commonly multiplexers/data selectors are available as standard i.c. packages such as the common TTL 74LS151 8-input to 1 line multiplexer or the TTL 74LS153 Dual 4-input to 1 line multiplexer. Multiplexer circuits with much higher number of inputs can be obtained by cascading together two or more smaller devices.

Multiplexer Summary

Then we can see that **Multiplexers** are switching circuits that just switch or route signals through themselves, and being a combinational circuit they are memoryless as there is no signal feedback path. The multiplexer is a very useful electronic circuit that has uses in many different applications such as signal routing, data communications and data bus control

Explore Litigation Insights

Docket Alarm provides insights to develop a more informed litigation strategy and the peace of mind of knowing you're on top of things.

Real-Time Litigation Alerts

Keep your litigation team up-to-date with **real-time alerts** and advanced team management tools built for the enterprise, all while greatly reducing PACER spend.

Our comprehensive service means we can handle Federal, State, and Administrative courts across the country.

Advanced Docket Research

With over 230 million records, Docket Alarm's cloud-native docket research platform finds what other services can't. Coverage includes Federal, State, plus PTAB, TTAB, ITC and NLRB decisions, all in one place.

Identify arguments that have been successful in the past with full text, pinpoint searching. Link to case law cited within any court document via Fastcase.

Analytics At Your Fingertips

Learn what happened the last time a particular judge, opposing counsel or company faced cases similar to yours.

Advanced out-of-the-box PTAB and TTAB analytics are always at your fingertips.

API

Docket Alarm offers a powerful API (application programming interface) to developers that want to integrate case filings into their apps.

LAW FIRMS

Build custom dashboards for your attorneys and clients with live data direct from the court.

Automate many repetitive legal tasks like conflict checks, document management, and marketing.

FINANCIAL INSTITUTIONS

Litigation and bankruptcy checks for companies and debtors.

E-DISCOVERY AND LEGAL VENDORS

Sync your system to PACER to automate legal marketing.

WHAT WILL YOU BUILD? | **sales@docketalarm.com** | **1-866-77-FASTCASE**

fastcase®
Smarter legal research.