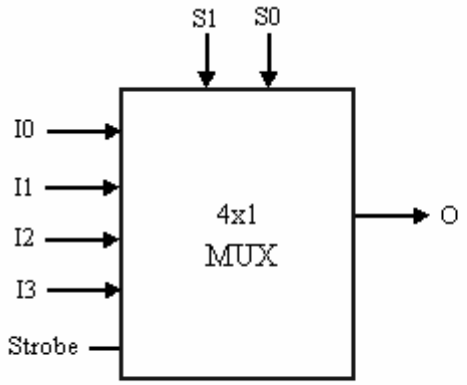
Multiplexer/Demultiplexer

7.1 Objectives:

To familiarize students with the structure and the operation of both Multiplexer and Demultiplexer. Students will design and build these devices using AND gates, also they should learn how to implement a large Multiplexer using a small Multiplexer as the building block.

7.2 Background Information:

Multiplexer (MUX), sometimes called Data selector, is a combinational logic circuit that selects one of 2^n inputs on the and route it to the output. It has 2^n inputs, n select lines (selectors) that identify which input will be provided to the output, and only one output. Figure 7.1 shows the block diagram and the truth table for a 4x1 MUX.



Strobe	S_1	S_0	O
0	X	X	0
1	0	0	I_0
1	0	1	I_1
1	1	0	I_2
1	1	1	I_3

Figure 7.1 Block Diagram & Truth Table of 4x1 MUX

Large multiplexer can be implemented using smaller size multiplexers. For example, consider a 8x1 MUX, this multiplexer can be implemented using two 4x1 MUXs one 2x1 MUX as shown in Figure7.2.

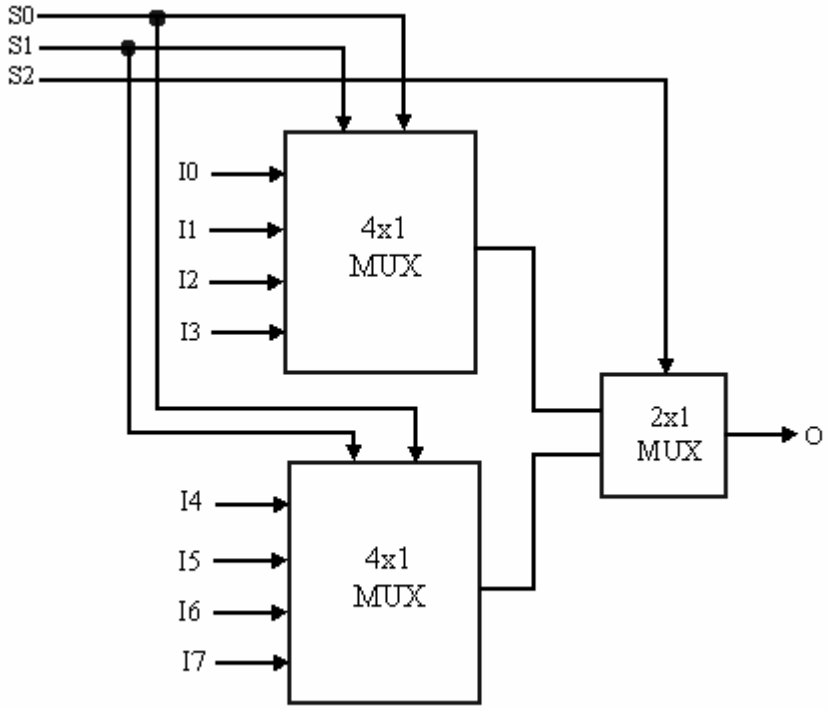


Figure 7.2 Implementation of 8x1 MUX using 4x1 and 2x1 MUXs

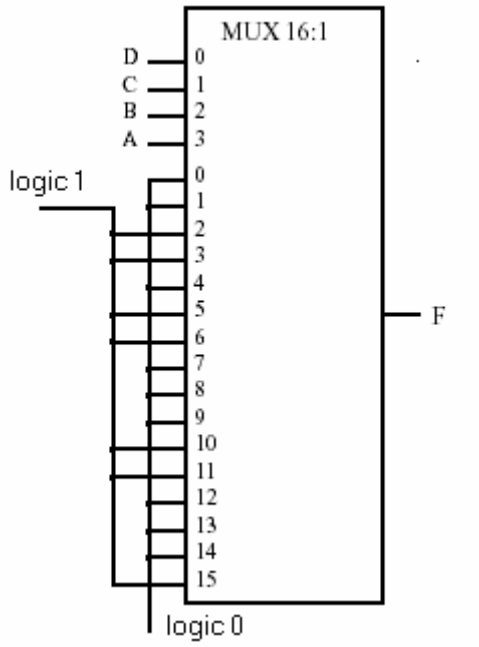
Implementation of Boolean Functions using Multiplexers

While Multiplexers are primarily thought of as "data selectors" because they select one of several inputs to be logically connected to the output, they can also be used to implement Boolean functions.

We can implement any Boolean function of x variables using a 2^x input MUX. Multiplexers can be used more effectively by using some forms of functional decomposition; meaning we can implement a 4-variable function using 8-to-1 MUX by using three of the variables as select inputs and feeding an appropriate function of the fourth variable to the data inputs of the MUX.

Consider the following truth table that describes a function of 4 Boolean variables.

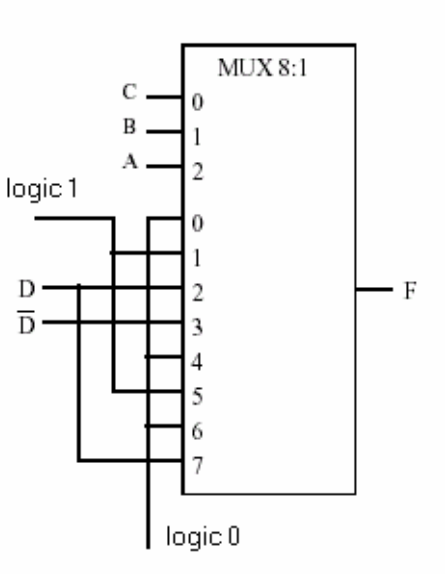
A	B	C	D	F
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	1
0	1	0	0	0
0	1	0	1	1
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	1
1	0	1	1	1
1	1	0	0	0
1	1	0	1	0
1	1	1	0	0
1	1	1	1	1



A 16x1 MUX with *A*, *B*, *C*, and *D* applied to its S_3, S_2, $S1$, and S_0 inputs respectively would select one of its 16 inputs for each of the 16 possible combinations of *A*, *B*, *C*, and *D*. We can implement the function described by the truth table by connecting a logic 1 or a logic 0 to each of the MUX inputs corresponding to the required value of the function associated with the combination of *A*, *B*, *C*, and *D* that selected the input. Therefore, the inputs to the MUX will be the same as the *F* entries in the truth table provided *A*, *B*, *C*, and *D* are connected to the Multiplexer select inputs in the right order.

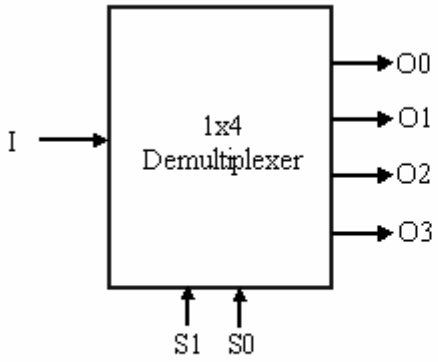
Also we implement the above function using 8-to-1 MUX, the one you just constructed in the lab. If we choose to connect *A*, *B*, and *C* to the select lines of the MUX, then we need to feed the MUX inputs with values that are function of D. To do this we partition the truth table into sections where *A*, *B* and *C* have the same value as shown below.

A	B	C	D	F	
0	0	0	0	0	0
0	0	0	1	0	
0	0	1	0	1	1
0	0	1	1	1	
0	1	0	0	0	*D*
0	1	0	1	1	
0	1	1	0	1	$\overline{D}$
0	1	1	1	0	
1	0	0	0	0	0
1	0	0	1	0	
1	0	1	0	1	1
1	0	1	1	1	
1	1	0	0	0	0
1	1	0	1	0	
1	1	1	0	0	*D*
1	1	1	1	1	



Demultiplexer:

The Demultiplexer is combinational logic circuit that performs the reverse operation of Multiplexer. It has only one input, n selectors and 2^n outputs. Depending on the combination of the select lines, one of the outputs will be selected to take the state of the input. Figure 7.3 shows the block diagram and the truth table for 1x4 Demultiplexer. By applying logic '1' to the input, the circuit will do the same function of the typical 2-to-4 Decoder.



S_1	S_0	O_0	O_1	O_2	O_3
0	0	I	0	0	0
0	1	0	I	0	0
1	0	0	0	I	0
1	1	0	0	0	I

Figure 7.3 Block Diagram & Truth Table for 1x4 Demultiplexer

7.3 Equipments Required:

Universal Breadboard
Wire kit
1x 74153 DUAL 4-TO-1 LINE DATA SELECTORS/MULTIPLEXERS
1x 74151 8-TO-1 LINE DATA SELECTORS/MULTIPLEXERS
1x 8-Position DIP Switches.
6x Carbon-film resistors (1-10 kΩ)
1x Carbon-film resistors (470 Ω)
1x LED

7.4 Procedures:

1. Verify the functionality of 74153 TTL chip by trying all input combinations filling the following truth table:

Strobe	S_1	S_0	O

2. Implement the following Boolean function using 8x1 and 4X1 MUXs.

F = x y z + x'yz' + xy'z + x'y'z'

x	y	z	F
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Questions:

1. What is the difference between Multiplexer and Demultiplexer?
2. Why the input lines of the MUX do not appear in the truth table with its logic values?
3. Construct a 16x1 MUX using 8x1 and 4x1 MUXs.
4. Implement the following Boolean function using:
   a. 8x1 MUX
   b. 4x1 MUX

$$F = AB\overline{C} + \overline{A}B\overline{C} + \overline{A}BC + A\overline{B}C$$

5. Give a summary of the points you have learned from this experiment.

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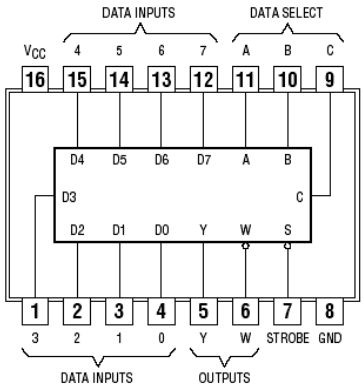
8-TO-1 LINE DATA SELECTORS/MULTIPLEXERS



FUNCTION TABLE

INPUTS				OUTPUTS	
SELECT					
C	B	A	$\overline{G}$	Y	W
X	X	X	H	L	H
L	L	L	L	D0	$\overline{D0}$
L	L	H	L	D1	$\overline{D1}$
L	H	L	L	D2	$\overline{D2}$
L	H	H	L	D3	$\overline{D3}$
H	L	L	L	D4	$\overline{D4}$
H	L	H	L	D5	$\overline{D5}$
H	H	L	L	D6	$\overline{D6}$
H	H	H	L	D7	$\overline{D7}$

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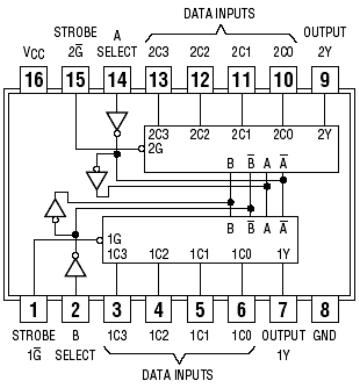
DUAL 4-LINE TO 1-LINE DATA SELECTORS/MULTIPLEXERS



FUNCTION TABLE

SELECT INPUTS		DATA INPUTS				STROBE	OUTPUTS
B	A	C0	C1	C2	C3	$\overline{G}$	Y
X	X	X	X	X	X	H	L
L	L	L	X	X	X	L	L
L	L	H	X	X	X	L	H
L	H	X	L	X	X	L	L
L	H	X	H	X	X	L	H
H	L	X	X	L	X	L	L
H	L	X	X	H	X	L	H
H	H	X	X	X	L	L	L
H	H	X	X	X	H	L	H