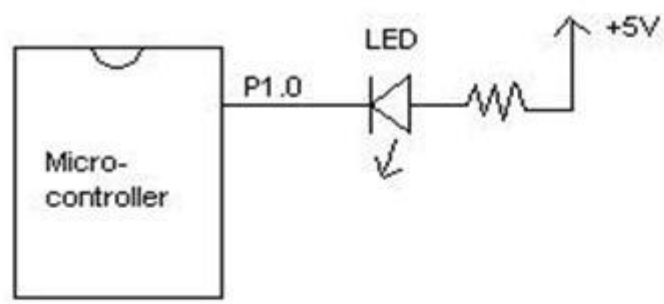
LED, LCD, and 7 – Segment Display

Display Using LED:

Light emitting diode (LED) is the most commonly used device for displaying the status of microcontroller pins. These display devices are commonly used for the indication of alarms, inputs and timers. There are two ways by we can connect LEDs to microcontroller unit. Those two ways are active high logic and active low logic. Active high logic means LED will be ON when port pin is 1 and LED will be OFF when pin is 0. Active low means LED will be OFF when port pin is 1 and LED will be ON when port pin is 0.



Dot Matrix LED Display:

Dot matrix LED display contains the group of LEDs as a two-dimensional array. They can display different types of characters or a group of characters. Dot matrix display is manufactured in various dimensions. Arrangement of LEDs in the matrix pattern is made in either of the two ways: Row anode-column cathode or Row cathode-column anode. By using this dot matrix display we can reduce the number of pins required for controlling all the LEDs.

A dot matrix is a two-dimensional array of dots used to represent characters, symbols and messages. Dot matrix is used in displays. It is a display device used to display information on many devices like machines, clocks, railway departure indicators etc.

An LED dot matrix consists of an array of LED's which are connected such that the anode of each LED are connected together in the same column and the cathode of each LED are connected together in the same row or vice versa. An LED dot matrix display can also come with multiple LEDs of varying colors behind each dot in the matrix like red, green, blue etc.

Here each dot represents circular lenses in front of LEDs. This is done to minimize the number of pins required to drive them. For example, an 8X8 matrix of LEDs would need 64 I/O pins, one for each LED pixel. By connecting all the anodes of LEDs together in a column and all the cathodes together in row, the required number of input and output pins reduced to 16. Each LED will be addressed by its row and column number.

Diagram of 8X8 LED Matrix using 16 I/O pins

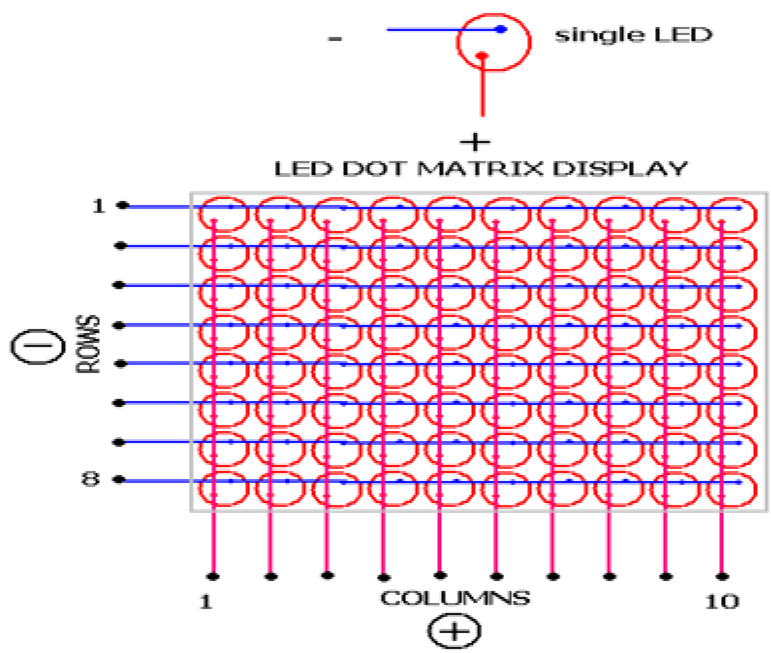


Diagram of 8X8 LED Matrix using 16 I/O pins

Controlling the LED Matrix:

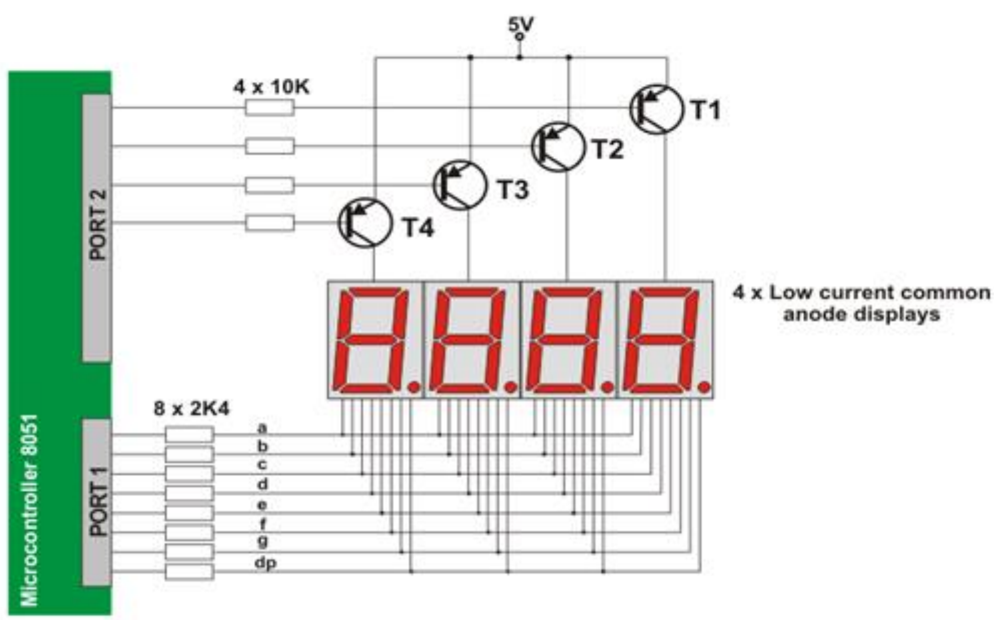
Since all the LEDs in a matrix share their positive and negative terminals in each row and column, it is not possible controlling of each LED at the same time. The matrix controlled through each row very quickly by triggering the correct column pins to light the desired

LED’s for that particular row. If the switching done with a fixed rate, humans can’t see the displaying message, because human eye can’t detect the images with in the milliseconds of time. Thus, the displaying of a message on LED matrix must be controlled, with the rows being scanned sequentially at a rate greater than 40 MHz while sending out the column data at the exact same rate. This kind of controlling can be done my interfacing the LED matrix display with the microcontroller.

Interfacing the LED Matrix Display with Microcontroller:

Choosing a microcontroller for interfacing with LED matrix display which is to be controlled is depends on the number of input and output pins needed for controlling all the LEDs in the given matrix display, the amount of current that each pin can source and sink and the speed at which the microcontroller can send out control signals. With all these specifications, interfacing can be done for LED matrix display with a microcontroller.

Using 12 I/O pins controlling the Matrix display of 32 LEDs



12 I/O pins controlling the Matrix display of 32 LEDs

In the above diagram each seven-segment display is having 8 LEDs. Hence the total number of LEDs is 32. For controlling all the 32 LEDs 8 information lines and 4 control lines are needed i.e. for displaying message on the matrix of 32 LEDs, 12 lines are needed when they are connected in matrix notation. Using the microcontroller instructions can be converted into signals which turn ON or OFF lights in the matrix. Then the required message can be displayed. By controlling with the microcontroller, we can change which color LEDs are lit at even intervals.

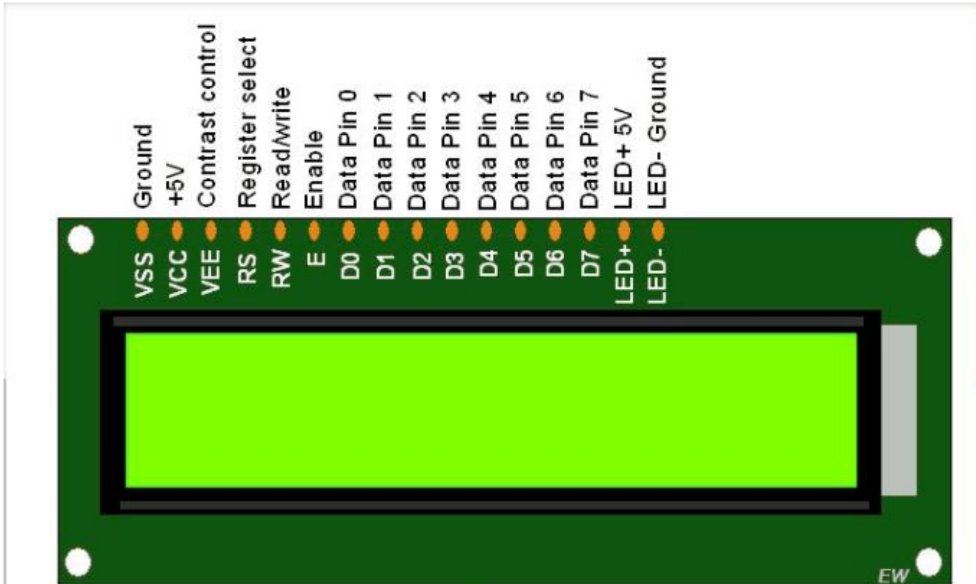
There are several options for choosing microcontroller and LED matrix. The easiest way is first choosing the LED dot matrix and then selecting a microcontroller which needs the requirements of LEDs to be controlled. Once these selections are completed, a major part is lies in programming to scan the columns and feed the rows with appropriate values for the LED matrix to display different patterns for displaying required message.

Liquid Crystal Display (LCD):

Liquid crystal display (LCD) has material which joins together the properties of both liquid and crystals. They have a temperature range within which the particles are essentially as mobile as they might be in a liquid, however are gathered together in an order form similar to a crystal.

The LCD is much more informative output device than a single LED. The LCD is a display that can easily show characters on its screen. They have a couple of lines to large displays. Some LCDs are specially designed for specific applications to display graphic images. 16×2 LCD (HD44780) module is commonly used. These modules are replacing 7-segments and other multi-segment LEDs. LCD can be easily interfaced with microcontroller to display a message or status of the device. It can be operated in two modes: 4-bit mode and 8-bit mode. This LCD has two registers namely command register and data register. It is having three selection lines and 8 data lines. By connecting the three selection lines and data lines with the microcontroller, the messages can be displayed on LCD.

LCD instructions set for controlling the LCD display using microcontrollers Interfacing 16×2 LCD display with 8051 microcontrollers.



LCD 16x2

In the above figure 3 selected lines EN, R/W, RS will be used for controlling the LCD display. EN pin will be used for enabling the LCD display for communicating with microcontroller. RS will be used for register selection.

When RS is set microcontroller will send instructions as data and when RS is clear microcontroller will send the instructions as commands. For writing data RW should be 0 and for reading RW should be 1.

LC

PIN Description

Pin	Symbol	Description	
1	V_{SS}	Ground	0 V
2	V_{CC}	Main power supply	+5 V
3	V_{EE}	Power supply to control contrast	Contrast adjustment by providing a variable resistor through V_{CC}
4	RS	Register Select	RS=0 to select Command Register RS=1 to select Data Register
5	R/W	Read/write	R/W=0 to write to the register R/W=1 to read from the register
6	EN	Enable	A high to low pulse (minimum 450ns wide) is given when data is sent to data pins
7	DB0	To display letters or numbers, their ASCII codes are sent to data pins (with RS=1). Also instruction command codes are sent to these pins.	8-bit data pins
8	DB1		
9	DB2		
10	DB3		
11	DB4		
12	DB5		
13	DB6		
14	DB7		
15	Led+	Backlight V_{CC}	+5 V
16	Led-	Backlight Ground	0 V

Interfacing 16×2 LCD with Microcontroller:

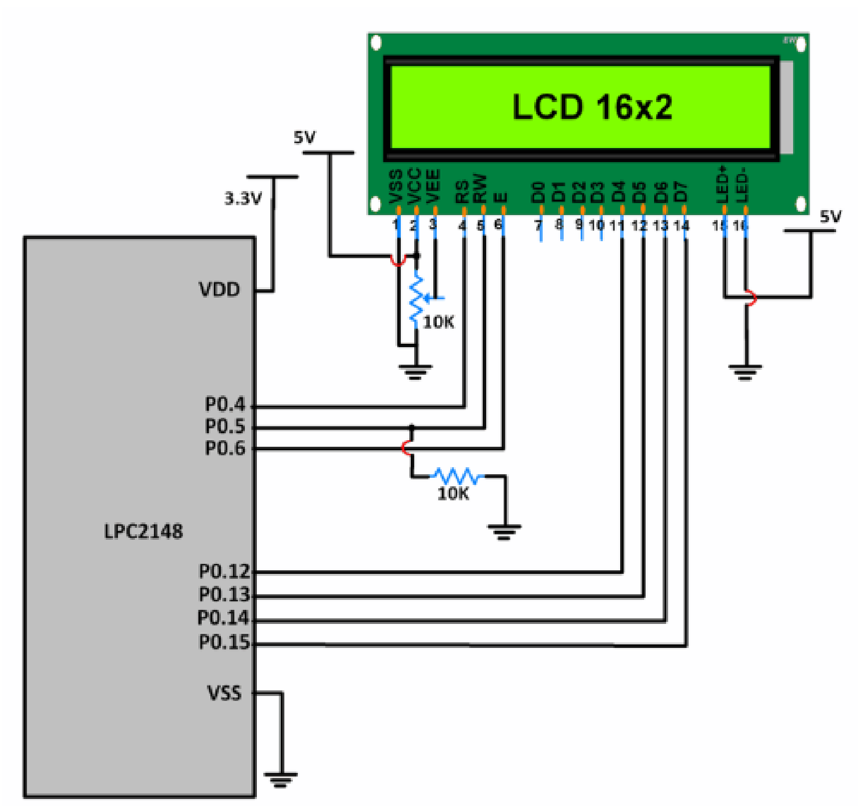
Many microcontroller devices are using smart LCD displays to output visual information. For an 8-bit data bus, the display requires a +5V supply plus 11 I/O lines. A 4-bit data bus requires supply line as well as 7 extra lines. When the LCD display is not enabled, data lines are tri-stated which means they are in a state of high impedance and this means they do not interfere with the microcontroller operation when display is not used.

The three control lines are referred to as EN, RS and RW.

- The EN (Enable) control line is used to send the data to the LCD. A high to low transition at this pin will enable the module.
- When RS or Register Select is low, the data is to be treated as a command instruction. When RS is high, the data being sent is displayed on the screen. For Instance, to display any character on the screen, we set RS high.
- When RW or Read/Write Control line is low, the information on the data bus is being written to the LCD. When RW is high, the program is effectively reading the LCD. RW line will always be low.

The data bus consists of 4 or 8 lines; it depends on the mode of operation selected by the user. The lines of an 8 bit data bus are referred to as DB0,DB1,DB2,DB3,DB4,DB5, DB6 and DB7.

Interfacing Diagram



Interfacing 16x2 LCD With LPC2148

Comparison Chart

Basis for Comparison	LED	LCD
Definition	PN-Junction device which discharge visible lights when an electrical charge passes through it.	It is an optical device used for displaying the information in the form of text and images.

Basis for Comparison	LED	LCD
Stand For	Light Emitting Diode	Liquid Crystal Display
Backlight	No backlight	Cold cathode fluorescent lamp provides backlight.
Resolution	High	Low
Power Requirement	More	Less
Display Area	Small	Large
Cost	High	Low
Material	Gallium arsenide phosphide.	Liquid crystals and glass electrodes.
Switching Time	Fast	Slow
Direct Current	Do not effects.	Reduces Life Span
Contrast Ratio	Low	High
Mercury	Not used	Used

BCD to 7 Segment Display

A seven-segment display is an electronic display device for displaying decimal numerals. Seven-segment displays are widely used in digital clocks, electronic meters and other electronic devices that display numerical information.

7 Segment Display

A 7 Segment LED display generally has 8 input connections, one for each LED segment and one that acts as a common terminal. There are 2 types of 7 Segment LED digital display.

Common Cathode Display – all the cathode connections of the LEDs are connected to ground. A logic '1' applied to the anode terminal of the individual segment illuminates it.

Common Anode Display – all the anode connections of the LEDs are connected to VCC. A logic '0' applied to the cathode terminal of the individual segment illuminates it.

BCD to 7 Segment Display Decoder

A BCD to Seven Segment decoder is a combinational logic circuit that accepts a decimal digit in BCD (input) and generates appropriate outputs for the segments to display the input decimal digit.

The truth table is extracted from the CD4511 IC datasheet. This truth table is interactive. Click on any row to see the respective 7 segment display output.

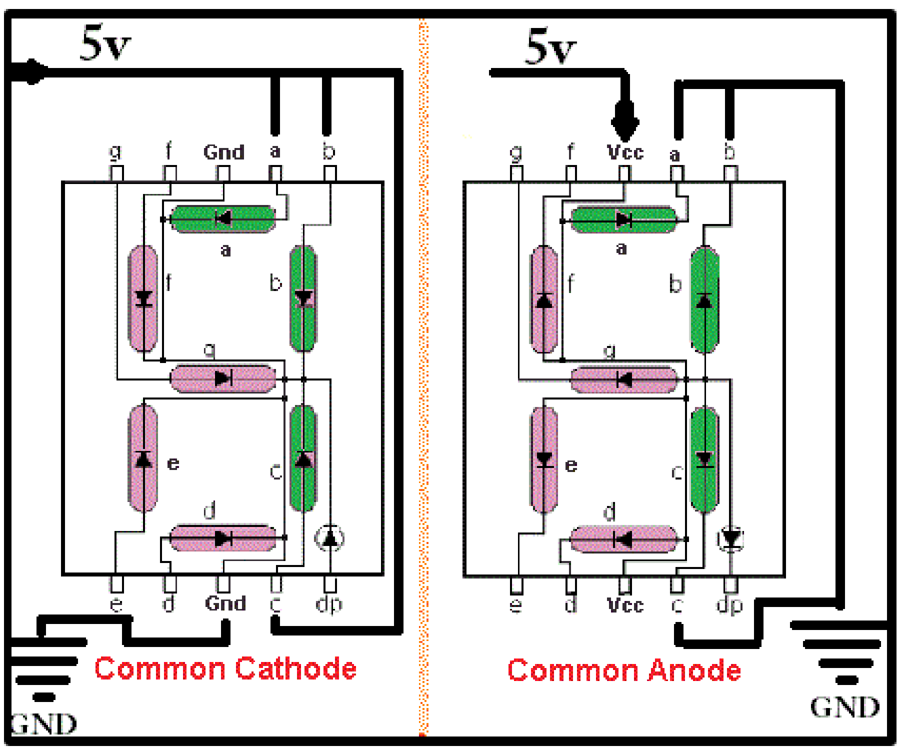
Truth Table

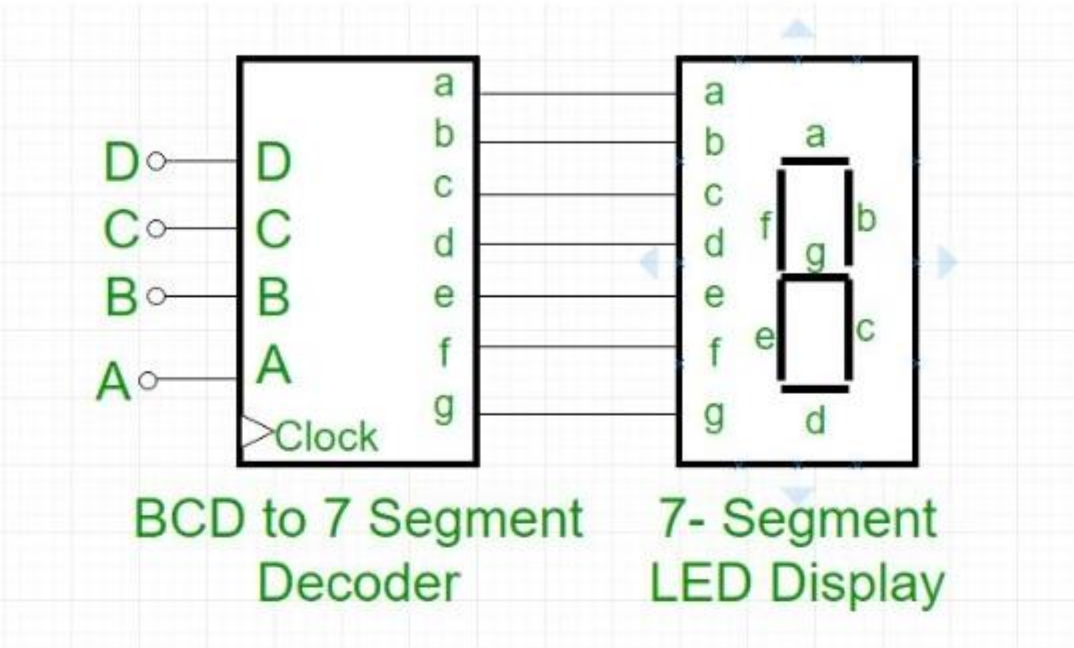
Display	D	C	B	A	a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
1	0	0	0	1	0	1	1	0	0	0	0
2	0	0	1	0	1	1	0	1	1	0	1
3	0	0	1	1	1	1	1	1	0	0	1
4	0	1	0	0	0	1	1	0	0	1	1
5	0	1	0	1	1	0	1	1	0	1	1
6	0	1	1	0	1	0	1	1	1	1	1
7	0	1	1	1	1	1	1	0	0	0	0
8	1	0	0	0	1	1	1	1	1	1	1
9	1	0	0	1	1	1	1	1	0	1	1

Blank	1	0	1	0	0	0	0	0	0	0	0
Blank	1	0	1	1	0	0	0	0	0	0	0
Blank	1	1	0	0	0	0	0	0	0	0	0
Blank	1	1	0	1	0	0	0	0	0	0	0
Blank	1	1	1	0	0	0	0	0	0	0	0
Blank	1	1	1	1	0	0	0	0	0	0	0

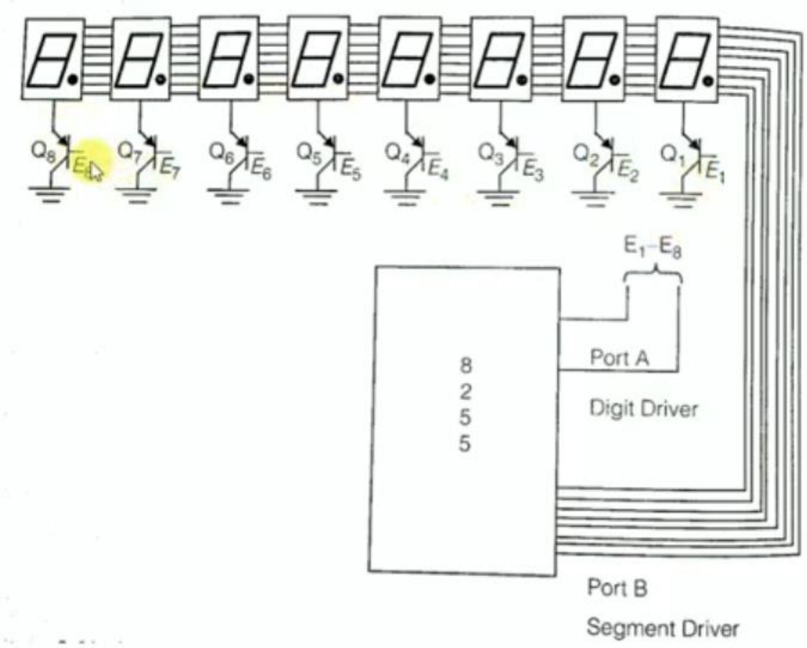
The input bits are D (MSB) to A (LSB) and the outputs are the segments a to g. For input values A to F, the display is blanked (outputs are all 0).

The logic circuit to implement the BCD to 7 Segment Decoder can be designed using the truth table




D
C
B
A
D
C
B
A
Clock
a
b
c
d
e
f
g
a
b
c
d
e
f
g
a
b
c
d
e
f
g
BCD to 7 Segment
Decoder
7- Segment
LED Display

Interfacing Multiple Seven Segment Display



	hex	h	g	f	e	d	c	B	a
a	5F	0	1	0	1	1	1	1	1
t	78	0	1	1	1	1	0	0	0
t	78	0	1	1	1	1	0	0	0
i	04	0	0	0	0	0	1	0	0
t	78	0	1	1	1	1	0	0	0
u	3E	0	0	1	1	1	1	1	0
d	5E	0	1	0	1	1	1	1	0
e	5B	0	1	0	1	1	0	1	1