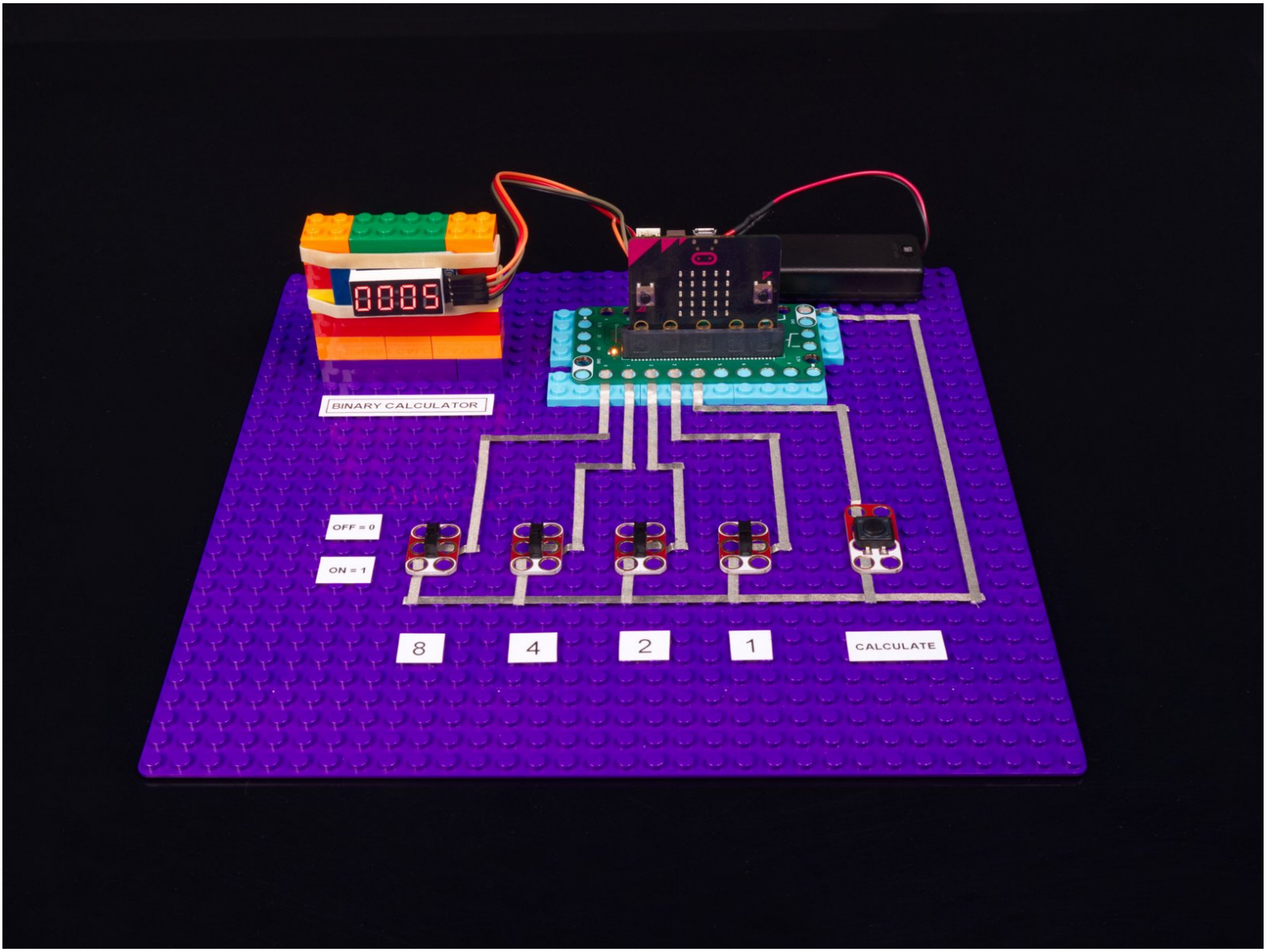
Binary Calculator

Use a micro:bit to build a Binary Calculator with a 4 bit register to learn how binary works and how to calculate a decimal number from a binary number.

Written By: Pete Prodoehl



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INTRODUCTION

Use a micro:bit to build a Binary Calculator with a 4 bit register to learn how binary works and how to calculate a decimal number from a binary number.

TOOLS:

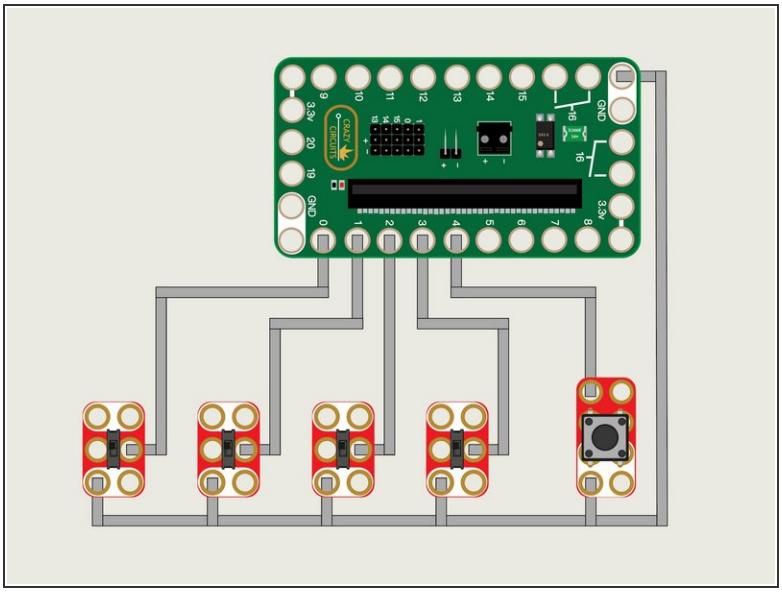
- Scissors (1)
- Computer (1)

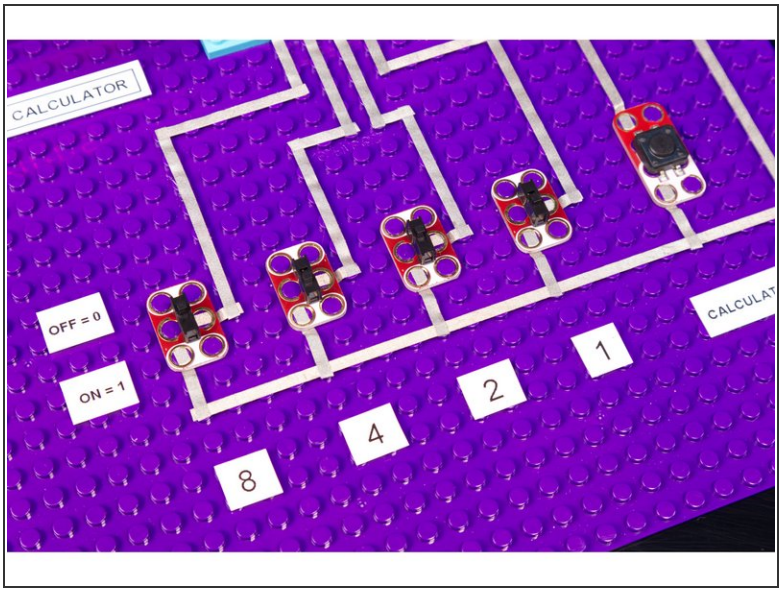
PARTS:

- Crazy Circuits Bit Board (1)
- micro:bit (1)
- Crazy Circuits Slide Switch Chip (4)
- Crazy Circuits Jumbo Pushbutton Chip (1)
- 7 Segment Display (1)
- Crazy Circuits Ribbon Cable (1)
- LEGO Baseplate (1)
- Misc LEGO Parts (1)
- Maker Tape (1)
  1/8"

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Step 1 — Build Your Circuit



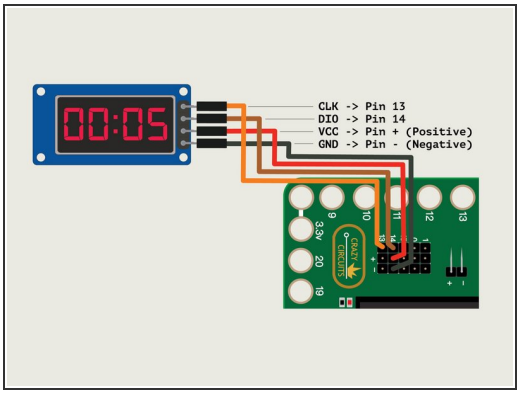


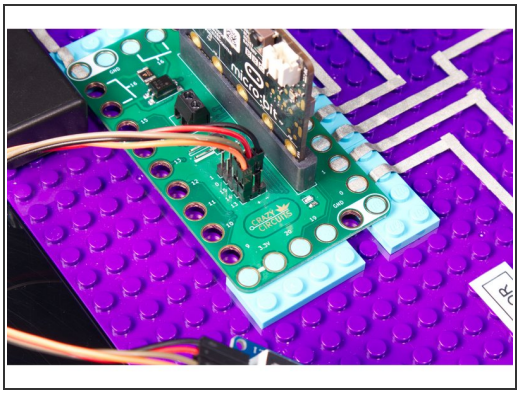
- We're going to build our circuit on a large LEGO baseplate. We'll need enough room for the Bit Board, 4 switches, one button, and the 7 Segment Display.
- Connect the four switches and the button as shown. Each needs to be connected to ground (GND) and to the appropriate pin.

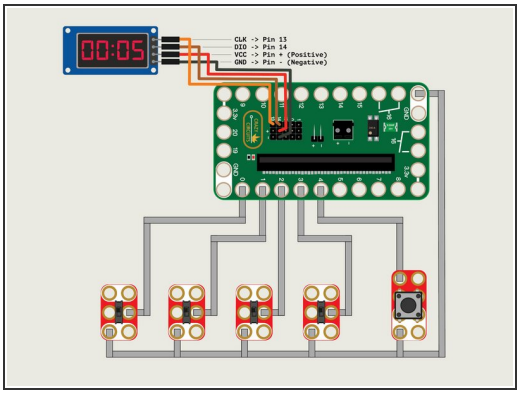
The PDF for this guide contains a lot of useful information about how binary works. Don't forget to check it out!

If you like this project check out our Binary Math Game guide!

Step 2 — Add 7 Segment Display







- Using Female/Female jumper wires connect the 7 Segment Display to the pins on the back of the Bit Board.

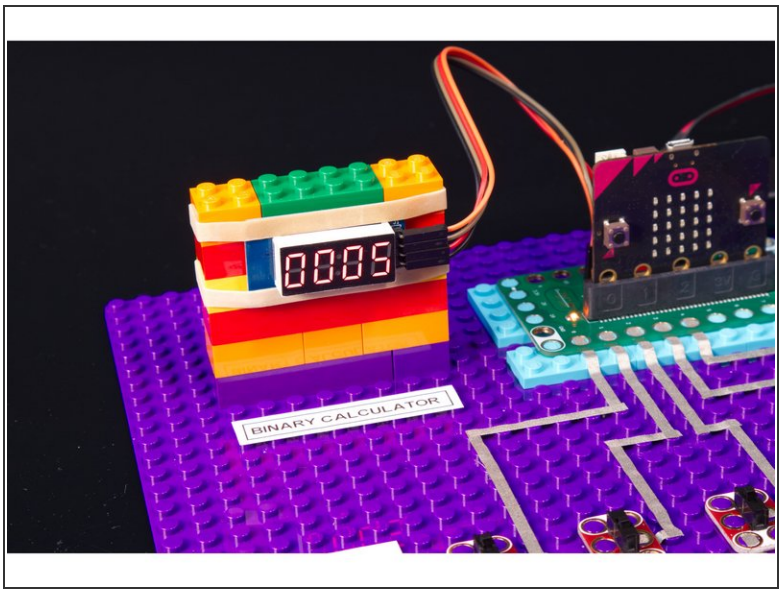
⚠ You can use whatever wire colors you like, but typically we try to use red for positive, black or green for negative (ground) and colors like orange, yellow, blue, brown, etc. for "signal" wires.

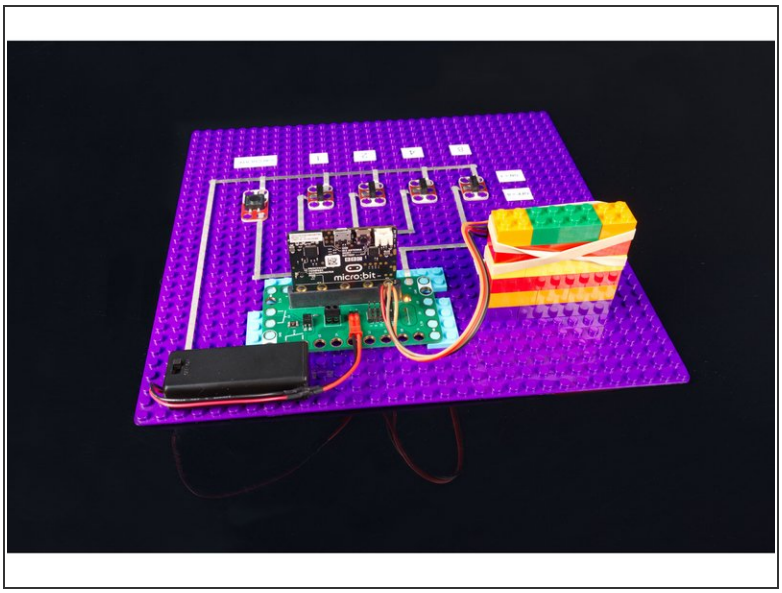
ⓘ You can position the components closer or farther apart, as long as you have space to run the Maker Tape to make all the connections.

⚠ Make sure each path of tape from a component to the Bit Board does not cross over another path. That would cause a **short circuit**!

Remember, Maker Tape is conductive on both sides, so if you cut a piece too short you can just stick another piece on top of it to continue your circuit.

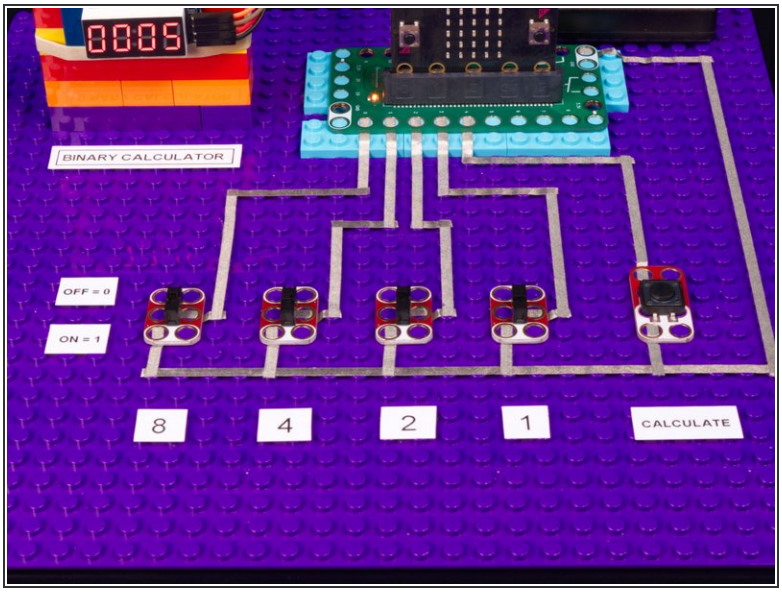
Step 3 — Attach 7 Segment Display

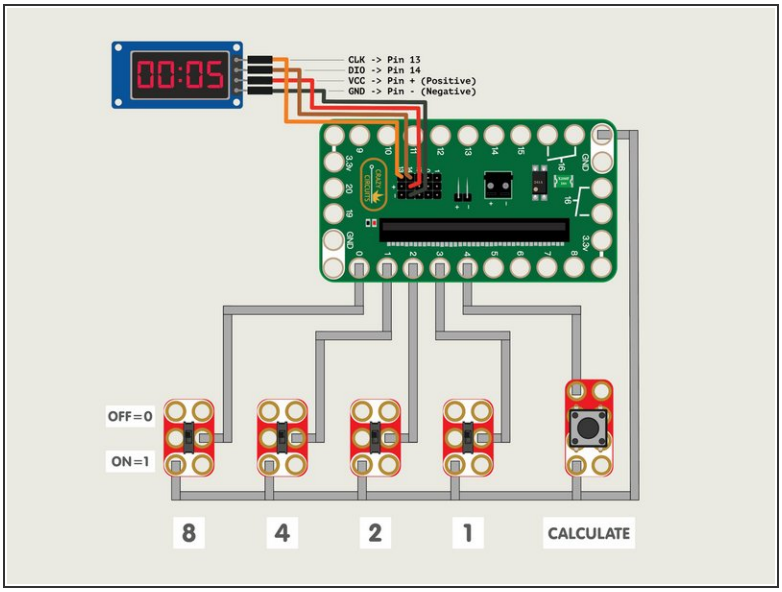




- Sometimes we build up a LEGO contraption to hold things like our 7 Segment Display, and sometimes we design and 3D print something... but sometimes simple is best, and some tape or a well placed rubber band does the job.
- For this project we just built up a small wall of LEGO bricks and mounted our sensor to it using a rubber band. (It works!)

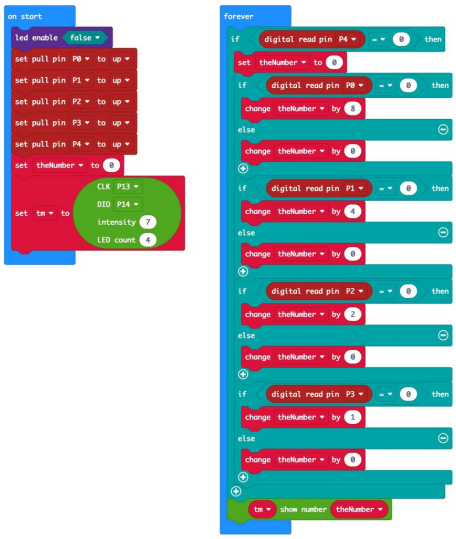
Step 4 — Add Labels





- This step is completely optional, but sometimes labels are helpful.
- Is the first switch 8 or is it 1? Is the switch on when it's up or down? With a few labels you won't have to remember! :)

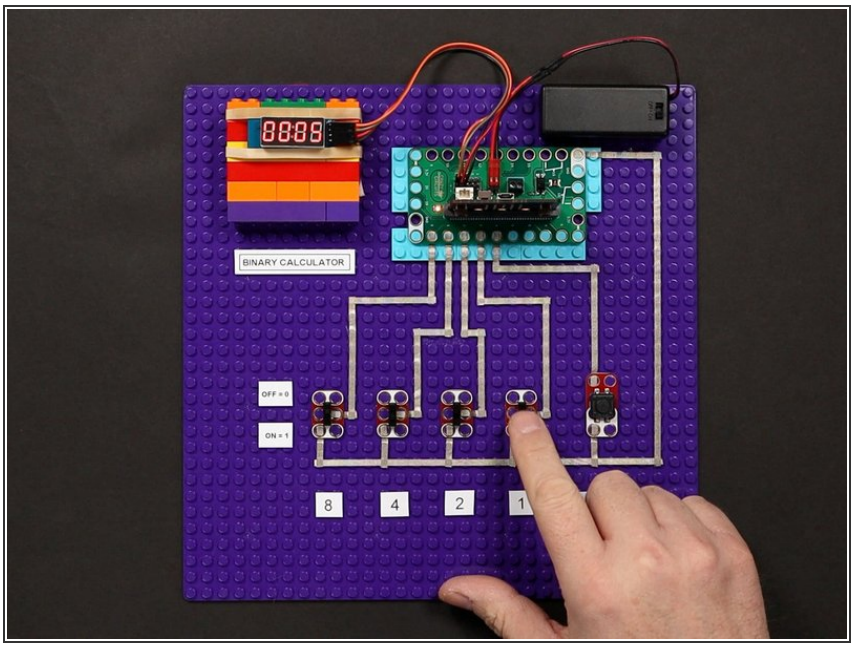
Step 5 — Load the Code



- Connect a USB cable to the micro:bit and then plug it into your computer.
- We'll be using makecode.microbit.org to program our board. It uses a simple drag and drop block interface.
- We're going to load the following code for our **Binary Calculator** program: https://makecode.microbit.org/_avbceA0oH...

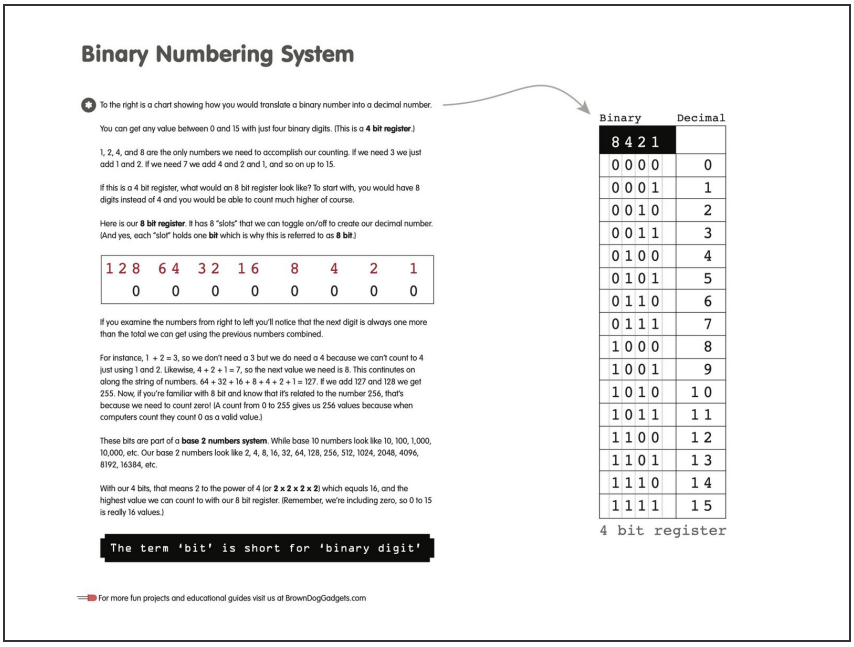
The attached PDF for this guide goes into great details explaining the code and what each section does.

Step 6 — Test it Out!



- Once you've got the code loaded on the micro:bit you can test it out.
- For this project you can either power the Bit Board using a 2 AAA battery pack, or by keeping the USB cable plugged directly into the micro:bit
- Can you step through the sequence to count from 0 to 15 by selecting the position of each switch and pressing the Calculate button? Challenge your friends to see who can do it faster, or who can do it without making any mistakes.

Step 7 — Take it Further



Binary Numbering System

To the right is a chart showing how you would translate a binary number into a decimal number.

You can get any value between 0 and 15 with just four binary digits. (This is a **4 bit register**.)

1, 2, 4, and 8 are the only numbers we need to accomplish our counting. If we need 3 we just add 1 and 2. If we need 7 we add 4 and 2 and 1, and so on up to 15.

If this is a 4 bit register, what would an 8 bit register look like? To start with, you would have 8 digits instead of 4 and you would be able to count much higher of course.

Here is our **8 bit register**. It has 8 "slots" that we can toggle on/off to create our decimal number. (And yes, each "slot" holds one **bit** which is why this is referred to as **8 bit**.)

128	64	32	16	8	4	2	1
0	0	0	0	0	0	0	0

If you examine the numbers from right to left you'll notice that the next digit is always one more than the total we can get using the previous numbers combined.

For instance, 1 + 2 = 3, so we don't need a 3 but we do need a 4 because we can't count to 4 just using 1 and 2. Likewise, 4 + 2 + 1 = 7, so the next value we need is 8. This continutes on along the string of numbers. 64 + 32 + 16 + 8 + 4 + 2 + 1 = 127. If we add 127 and 128 we get 255. Now, if you're familiar with 8 bit and know that it's related to the number 256, that's because we need to count zero! (A count from 0 to 255 gives us 256 values because when computers count they count 0 as a valid value.)

These bits are part of a **base 2 numbers system**. While base 10 numbers look like 10, 100, 1,000, 10,000, etc. Our base 2 numbers look like 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024, 2048, 4096, 8192, 16384, etc.

With our 4 bits, that means 2 to the power of 4 (or **2 x 2 x 2 x 2**) which equals 16, and the highest value we can count to with our 8 bit register. (Remember, we're including zero, so 0 to 15 is really 16 values.)

The term 'bit' is short for 'binary digit'

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Binary	Decimal
8421	
0000	0
0001	1
0010	2
0011	3
0100	4
0101	5
0110	6
0111	7
1000	8
1001	9
1010	10
1011	11
1100	12
1101	13
1110	14
1111	15

4 bit register

- This binary calculator has a 4 bit register and counts to 15. How high could you count with a 16 bit register? How about a 32 bit register?
- The attached PDF has a good explanation of bits and how binary systems work, including a handy chart you can use to visualize how to set the switches to get the desired decimal.

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