CAUSES, EFFECTS AND SOLUTIONS OF FLOATING IN MICROCONTROLLERS

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Abstract – As t*he technology increases day by day, we all prefer the devices which are smaller in size and with extraordinary performance. Since the demand increases, new technologies and jaw dropping inventions were evolved. One of the major advancements in technology is the invention of microprocessor, thereby the age of computers begins. Microcontroller is an embedded device with microprocessor, programmable memory, and peripheral devices. In this modern age, microcontrollers are everywhere beginning with electronic toys to ingenious interstellar satellites. As we are getting closer and closer to the productivity, eventually lot of problems also arrived one being the problem with the concept of floating. The main objective of the research is to give a solution for the problem of floating digital pins which evolved in accordance with the wide usage and enormous applications of the microcontroller.*

Key Words: Microcontroller, microprocessor, floating pins, EMI radiation, floating input, problems of floating pins, effects of floating, causes of floating, solutions of floating.

1. INTRODUCTION

Nowadays microcontrollers are cheap and readily available for hobbyists, with large online communities around certain processors. Since usage hikes, demand will do ultimately, and microcontrollers became very popular in simplifying human life and to nullify the effort by humans. It is nothing but a pre-programmable embedded device which can make appropriate decisions by using predefined algorithms. They can take inputs from the devices they control, and retain the control by sending commands to those devices. As microcontrollers plays a very prominent role in electronic industry, lots of discussions came in to limelight. One of the pinnacle problems for such device is instability in the input signal. The main objective of this research is to find out the causes of instability and to take appropriate measures to avoid that instability.

1.1 Floating pins in a microcontroller

Circuits have inputs and outputs. The voltages on the input pins were analysed by the circuit to generate voltages on the output pins. For example, let us consider a simple **AND** logic gate, the simplest **AND** gate has two inputs and one output. Let us call inputs as **A** and **B** if both **A** and **B** are high, output should be high. If either **A** or **B** are low, then the output will also be low. But what happens if one of the inputs is left unconnected, so no signal is applied to it at all? We say it's left to float, which means it's in an indeterminate state: may be high or low or somewhere in the middle it swings in between high and low in fitful manner. Then the output may be unreliable, and that's not what we usually want. This phenomenon of swapping from high to low and vice versa is known as floating, and the pin of the microcontroller which floats is called as floating pin.

1.2 Practical approach to floating pins

Now usually we might think if something is floating that's like a good thing our ship crashes and we are floating in the ocean, hey we're floating that's better than sinking, alright well with electronics that's not the case. So, the bottom line is floating pins are bad. With this practical approach, we are going to seek the answer for some major dilemmas like why and what is floating. Let's go ahead and setup a reference for this conversation. Sometimes if we got our microcontroller and want to read some type of digital input, so for example let's say we have a push button and we want to tell whether or not the push button is being pressed down or it's not being pressed or maybe we have some other type of sensor that gives you like a binary answer either on or off. We will start by just looking at the microcontroller board by itself, refer fig-1. Now if nothing connected, we'll use a multimeter to measure the value of certain pin, which is set to input and we see zero volts, or approximately zero volts.

Fig -1: Sample measurement

Now after dumping a quick program to the microcontroller to print the value at that particular pin over the serial monitor, let us see what we have observed in fig-2.

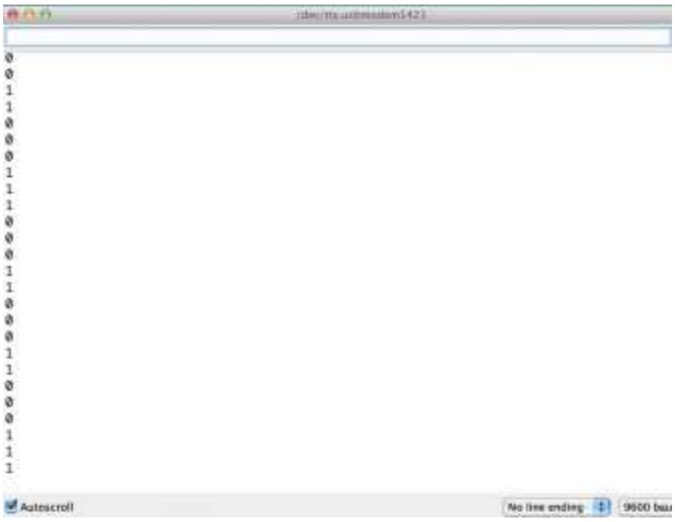

Fig -2: Sample measurement over serial monitor

What the hack? Why it is changing randomly in between ones and zeroes? It looks pretty random. We can tell there's maybe some random sequence to this but for the most part it looks just like noise. So, what is going on at that particular pin when nothing connected? We call this pin with nothing connected as a floating pin.

2. Deep analysis of floating pins

Instead of a multimeter or a serial monitor, let's see the signal of the pin using an oscilloscope ref fig-3.

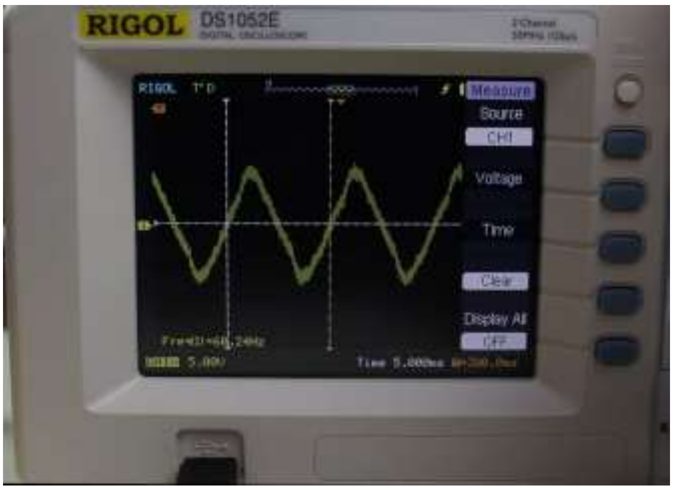

Fig -3: Signal at floating pin over oscilloscope

Oh wow! Check that out there is a big signal there, ref fig-3. Even if you can't read oscilloscope screen yet, you can guess that this does not look right. Adding a frequency measurement, we can see that the signal is around 60 Hertz ref fig-4.

Fig -4: Frequency measurement over oscilloscope

2.1 Causes of floating

Essentially, the floating input will definitely cause erratic chip operation or unpredictable behavior. I have noticed some chips froze by simply moving my hand closer to the board and some would have different startup behavior each time the board would powerup. On deep examination and analysis of floating pins, I can say that floating pins are very sensitive to electrostatic charges and electromagnetic radiations ref fig-5. Since we are all surrounded with EMI radiations, and so many noises in our environment, this energy finds its way into the input pins since floating pins are very sensitive to those changes.

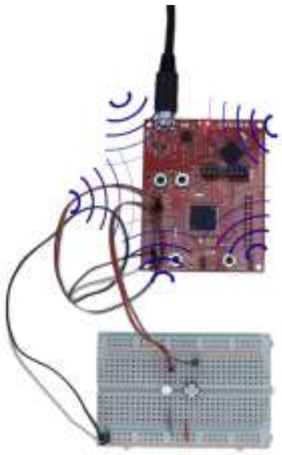

Fig -5: EMI radiations causing floating

2.2 Solution for floating pins

The most reliable solution for the problem of floating is to use pull-up and pull-down resistors. Before going to discuss about pull-up and pull-down resistors, let us think what is happening when any one the input pin was left unconnected. Since floating pins are very sensitive to the changes in EMI radiations surrounding them, it is not recommended to left any one of the pins in unconnected state once after it was declared as input pin, ref fig-6. In fig-6 whenever if the button is closed, input pin was grounded and if the button opened, input pin will float and consider garbage values. So once if the pin was declared as the input pin, microcontroller will expect and read certain input at that particular pin at each and every fraction of a second, and it will consider any of the signals at that particular pin whether it may be a user defined signal or due to any electromagnetic radiations etc. So, whenever user is not using the input pin, we need to keep the input pin busy rather than to consider any unwanted garbage signals from any of the anonymous sources. Now the big concern is how to keep an input pin busy? There the idea of pull-up resistors came in to limelight.

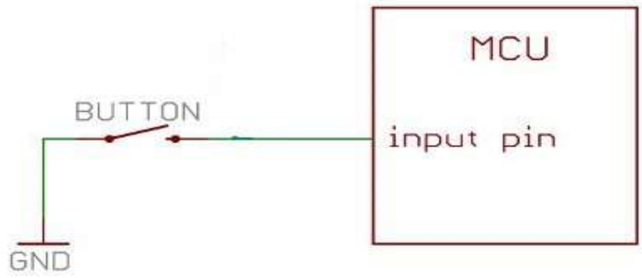

Fig -6: Floating pin of a microcontroller unit

2.3 Pull-up resistor

The resistor which pulls up the input signal to high at the input pin whenever if it is in unconnected state is simply known as the pull-up resistor. In fig-6 whenever if the button is not closed, input pin will read some unwanted signals. In order to avoid that we need to keep the pin connected to digital high by using pull-up resistor ref fig-7. With a pull-up resistor, the input pin will read a high state when the button is not pressed. In other words, a small amount of current will flow between VCC and the input pin, thus keeping the input pin at a voltage nearly equal to VCC.

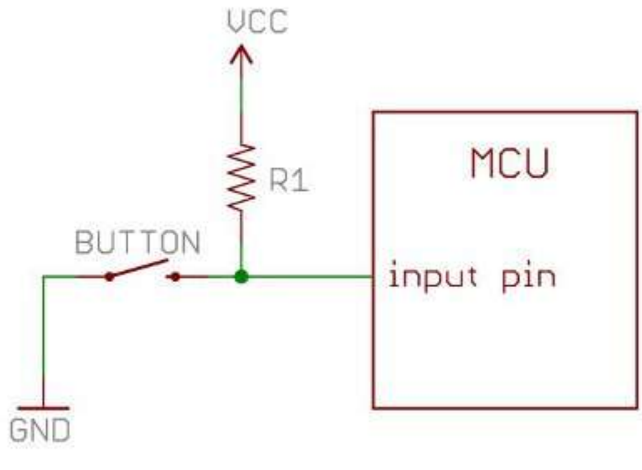

Fig -7: Input pin using pull-up resistor

In fig-7 the resistor R1 is known as the pull-up resistor. When the button is pressed, it connects the input pin directly to ground. The current flows through the resistor to ground, thus the input pin reads low state. Do we need to use pull-up resistor for sure? The answer is exactly yes because if the pull-up resistor is not there, whenever if the button is not closed, VCC will get direct contact with the input pin which can cause permanent or temporary damage to the microcontroller unit.

2.4 Pull-down resistor

The resistor which pulls down the input signal to low at the input pin whenever if it is in unconnected state is simply known as the pull-down resistor.

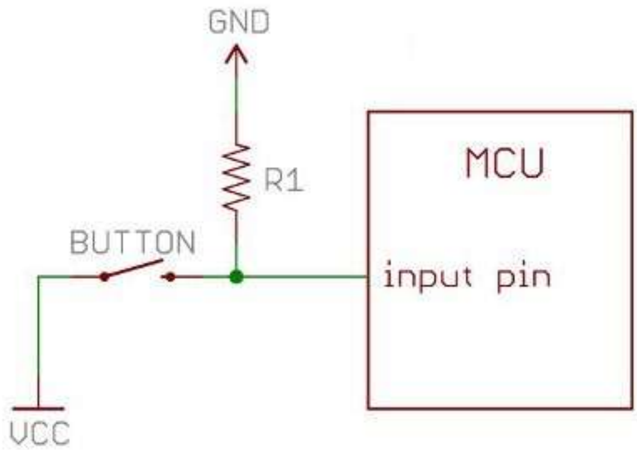

Fig -8: Input pin using pull-down resistor

In fig-8, R1 is called as the pull-down resistor. Whenever if the button is not closed, the input signal will be pulled down to low since it is in contact with ground. If the button is closed, small amount of current will flow from VCC to ground which will excite the input pin to high.

2.5 Choosing the value of the resistor

We have learned how to avoid input pins to receive garbage signals from unwanted sources by using pull-up and pull-down resistors. Now one of the biggest concerns is how much is the value of that resistor? To calculate this let's have a look at some basic laws which we have learned in our school age. By using ohms law, equation can be written as follows.

$$V_{CC} = (current\ through\ R1) \cdot R1$$ eq-2.5.1

$$R1 = \frac{V_{CC}}{current\ through\ R1}$$ eq-2.5.2

By depending on the above equations, value of the desired resistor will be calculated. Generally, microcontroller units have the voltage range of 5V and current range of 1mA. So, by taking these values as reference, let us calculate the value of the resistance.

$$\frac{5\text{V}}{0.001\text{A}} = 5\text{k}\,Ohms$$

eq-2.5.3

So, the value of the resistor is around 5K Ohms. In general, pull-up resistors are most common when compared to the pull-down resistors due to wide range of applications.

3. CONCLUSION

In conclusion, noise can couple onto a high impedance floating input and cause it to switch erratically and consume power unnecessarily. In order to avoid this problem some necessary steps were mandatory including the usage of pull-up resistor or pull-down resistor.

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BIOGRAPHIES

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