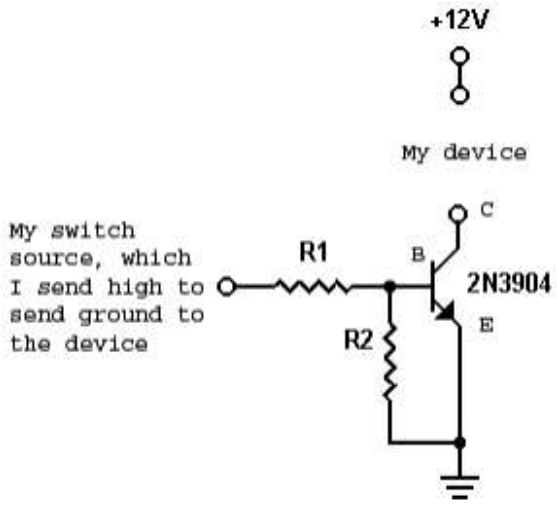
Why do you need 2 resistors when hooking up a transistor as a switch

Asked 10 years, 9 months ago Modified 4 years, 2 months ago Viewed 11k times

What is the point of R2 in the following diagram:

Here's a schematic:



I get that R1 controls the current to the Base, but what does R2 do?

transistors resistors switches

edited Nov 4, 2013 at 17:23
Butzke
1,002 ● 12 ● 27

asked Dec 3, 2011 at 19:51
Tyler DeWitt
729 ● 1 ● 6 ● 8

See also this question. – AndrejaKo Dec 3, 2011 at 20:11

5 Answers

Sorted by: Highest score (default)

The R2 resistor is used to bring the voltage on the base into a known state. Basically when you turn the whatever source of current you have at the other side of R1 off, the whole line would go into an unknown state. It may pick up some stray interference and that may influence the operation of the transistor or the device on the other side or it may take some time for the voltage to drop just with just the transistor base. Also note that the source of the current going through R1 may leak and that may affect the way transistor operates.

With the R2, which is in configuration called pull-down resistor, we are certain that whatever

excess voltage there may be in the branch containing R1 will be safely conducted into ground.

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answered Dec 3, 2011 at 20:02

AndrejaKo

22.9k ● 25 ● 107 ● 181

1 Awesome, thanks. One clarifying detail (it's been a while since my EE classes...): When no voltage is applied at the node to the left of R1, does R2 act as a wire and pull the voltage at the Base to GnD (this is a general resistor question). Is it the behavior of a resistor to act like a wire with no current flowing through it? – Tyler DeWitt Dec 3, 2011 at 20:42

3 @Tyler DeWitt Well a wire is a resistor, so yes, a resistor would act like a wire. As far as I can see the main reason why we have significant resistance at R2 is to make sure that when voltage is applied left of R1, the majority of current goes into the base and not the ground. – AndrejaKo Dec 3, 2011 at 21:09

Additional note: In the input-disconnected case, R1 is a resistor, and since resistors follow Ohm's Law, and the resistor's current (I) is 0, then the voltage drop on the resistor must necessarily be 0 as long as R is not 0. Thus, the input will float to the base pin's voltage. – Mike DeSimone Dec 4, 2011 at 1:29

2 -1: Not correct. Without R2, the transistor would turn off, but slowly and dependent on the source's output voltage. – Jason S Dec 4, 2011 at 2:05

4 ...but your argument *is* exactly correct when applied to MOSFETs rather than bipolar transistors. – Jason S Dec 4, 2011 at 2:14

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There are two possible reasons:

1. As others have said, R2 acts as a pulldown in the case where the left end of R1 is left floating. This is useful in when whatever driving R1 might go to high impedance.
2. As a voltage divider. The B-E voltage of a silicon bipolar transistor is around 500-750mV when on. In some cases you might want a higher threshold for the control voltage to turn on the transistor. For example, if R1 and R2 are equal, then the transistor will start coming on at twice the voltage it would have without R2.

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answered Dec 3, 2011 at 20:24

Olin Lathrop

307k ● 36 ● 421 ● 892

I remember something about overdriving the base leading to so much saturation it took longer to turn the transistor back off. How did that work again? (I've been using MOSFETs so much I forgot some of my BJTs.) – Mike DeSimone Dec 4, 2011 at 1:23

1 2.b. or the source driving the B-E junction only guarantees that it puts out 0.9 V for a low, so you need to attenuate it to make sure that when it's off, it's really off. – endolith Feb 14, 2014 at 22:06

11

In addition to the reasons that Olin has mentioned, there's one more: R2 ensures that the transistor turns off rapidly.

Let's suppose you have a source which is not a switch, but a TTL circuit like a 74LS04. TTL circuits (at least the TI SN74LS04) have a minimum output high voltage of 2.4V and a maximum output low voltage of 0.4V. And suppose that R1 is 1K, and the Vbe "on" drop is about 0.6V.

That gives you a 1.8mA (=(2.4V-0.6V) / 1K) current to turn the transistor on, but only -0.2mA to turn the transistor off. Bipolar transistors do have parasitic capacitance that needs to be charged / discharged (not quite the same behavior as MOSFETs).

Now put R2 = 1K: this pulls 0.6mA out of a Vbe=0.6V transistor, yielding a turnon current of 1.2mA and a turnoff current of -0.8mA, so the turnoff behavior will be faster.

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answered Dec 4, 2011 at 2:13

Jason S

13.9k ● 3 ● 40 ● 66

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The obvious reason for it is to serve as a pull-down resistor, to make sure the base is held low (when there is no specific signal through R1) in order to avoid spurious switching. If there's any other reason for it, it's not jumping out at me.

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answered Dec 3, 2011 at 20:02

mindcrime

1,098 ● 8 ● 11

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As well as (and partially a part of) what is said by others, the transistor produces a base-emitter leakage current. With drive to R1 open circuit and R2 ommitted the base floats and the leakage current develops a voltage across the B-E junction which can turn the transistor on. R2 provides a path for this current. As the current is small R2 may be large and the actual value used is usually far smaller than needed. As long as R2 dissipates little energy compared to the energy in R1, having R2 in the 10's to 100 of kilohm range does no harm.

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answered Dec 4, 2011 at 6:47

Russell McMahon ♦

143k ● 18 ● 205 ● 377