

Re: transistors: so confusing!!

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- *From:* "Abstract Dissonance" <Abstract.Dissonance@hotmail.com>
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<cabraham01@xxxxxxx> wrote in message
<news:1139498176.687275.225870@xx>

Joe McElvenney wrote:

Andrew,

Something that has been confusing me no-end, and I just cant seem to grasp, is how a TRANSISTOR works!!!

You are not alone!

Try this, it is much closer to the truth although, as with most explanations, an over-simplification.

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The base and emitter form a diode.

Put a forward voltage across that diode and electrons will flow out of the emitter into the base (i.e. in a NPN transistor).

Now the base region is narrow and the base/collector junction is biased so as to attract electrons to it.

So, on the way to the base terminal, more than 90% of them are kidnapped by the collector and never get there. It acts like a narrow pipe with a big hole in it.

More voltage on the base, more emitter current and so more of it available to be diverted.

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There are two hang-ups that can cause confusion –

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1). Current flow in the collector is caused by a smaller current flow in the base.

But what causes that base current in the first place? It is of course the base to emitter voltage.

Essentially then, a transistor is a voltage (not a current) operated device although when working out biasing, it is convenient to stay with the 'current' model.

2). The collector–base region is reverse–biased.

Yes it is, but only for electrons trying to flow in from the collector. For the electrons in the base trying to get into the collector it is forward–biased.

Cheers – Joe

Dear friends,

Once again, the "VICE" issue has reared its head ("voltage–current/chicken–egg" or "voltage–current/cause–effect" to some folks). When motors, generators, transformers, LED's incandescent light bulbs, transistors, etc. are under examination, the VICE monster often shows up.

In a bjt, the base current I_b , and the base–emitter voltage V_{be} , ****mutually coexist****. They are interdependent, interactive, concurrent, mutual, simultaneous, inclusive, joined at the hip, etc. In other words one cannot exist without the other, but at the same time, one is not "caused" by the other. V_{be} does NOT "cause" I_b , and vice–versa. Examine the I–V curve of any p–n junction, whether it be a junction diode, gate–cathode terminals of an SCR, base–emitter junction of a bjt, LED, etc., and it is immediately obvious that the curve passes through the origin and does not touch either axis elsewhere. In other words, diode current I_d is zero only when diode voltage V_d is zero, and vice–versa. If one is non–zero, so is the other.

In spite of this, some have insisted, since day one, that current is "caused" by voltage. If that were the case (it isn't), then every electrical device in the universe would be "voltage operated" and nothing would be "current operated". We wouldn't even have to bother with these terms.

A bjt is a ***charge*** operated device. Charge must be injected into the forward biased b–e jcn, and the reverse biased c–b jcn. It takes energy, or work in order to move the charge. Voltage doesn't move the charge, energy does. Likewise with FETs. It takes energy, or work, to charge the gate to source terminals.

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So your saying without a voltage(difference) the charge would still move?

Um.. Voltage is defined as the change in potential energy between two points needed to move a "test" charge in an electric field between two points.

Hence it has everything to do with motion. One can argue that there is no potential difference between two points unless an electron is moving.

If an electron is moving in an electric field then it is doing so because there is a potential difference.

there are three explicit points involved in the definition: Distance, charge, and the electric field. Since current measures the rate of change of w.r.t to time past some point and since the speed of charge in a conductor is approximately constant then current approximately measures the amount of charge passing through a point at any given time.

If we consider a uniform electric field, say between two points a distance d apart and electrons are flowing between the two points with a constant velocity then

$$V = -q \cdot E \cdot d$$

and

$$I = a \cdot q$$

hence

$$V = I \cdot E \cdot d / a$$

or if since E, d, a are all constants in this problem we see that V is proportional to I .

i.e., ohms law in an ideal resistor.

in a transistor its the same thing except E and q are changing due(and they are related).

But definitely there is a relationship and you can't have one without the other. Voltage and energy are synonymous in the sense that you can't really have a potential difference without moving a charge. When you measure a voltage with your voltmeter you are actually measuring current flow on an extremely small scale and for all practical purposes you assume there is no current flow.

Its true though that you can't have voltage without current flow but the opposite is true too.

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With FETs, this charge and energy can be provided by either a low-impedance constant-voltage source, or a high impedance constant-current source. To keep it brief, a low-Z constant voltage source is better suited for driving a FET gate due to the high-Z of the gate. The v-source provides both V_{gs} and I_g , both necessary for FET operation.

With a bjt, I_b and V_{be} are also both needed for operation. A low-Z constant voltage source, or a high-Z constant-current source could provide both V_{be} and I_b . Again, for brevity, a high-Z constant-current source is better suited for driving the b-e junction due to its low-Z characteristic and temperature dependency of current. The constant i-source provides both I_b and V_{be} , both of which are absolutely indispensable.

All electrical devices require BOTH I and V working together in tandem in order to function. Some devices, depending on their terminal characteristics regarding impedance, temperature, etc., are more amenable to being driven by a constant I source vs. a constant V source, or vice versa. The constant I source provides BOTH I and V, as does a constant V source. Have I explained myself? Best regards.

Yeah. I think you just need to understand that ultimately voltage and energy related. They are exactly related by

$V = U/q$ where U is the change in potential energy and q is charge.

Otherwise everything else seems to make sense(which you happen to point). Just seems that you are implying in some cases that you can have current without a voltage.

I think ultimately current and voltage are one in the *same* but we view them from different perspectives. You can't have one without the other and there is a relationship between them. This relationship is sorta a transformation that depends on the physical constraints we impose on the electrons... they are related by an electric field and in some sense they the same manifestations of some singular phenomena. (sorta like the wave particle duality idea or special theory of relativity or even how the electric and magnetic fields are manifestations of the same thing(and are equivalent in some sense depending on your "perspective"))

Anyways,

Claude

Jon

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