Fundamentals of Power Electronics
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Lecture - 82
BJT base drive example

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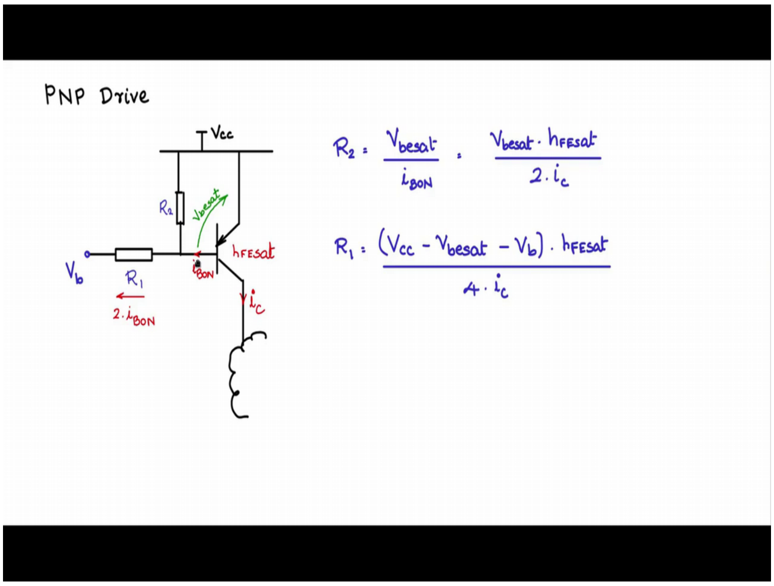

We saw the base drive circuit 1 where we had used an NPN BJT. Along similar lines we can also use a PNP BJT. It is the dual of the NPN circuit. The PNP BJT also is quite popular in base drive circuits as you will see when we develop other base drive circuits.

Now, here you have this emitter, base and collector and the PNP is a rail driven that is positive power supply driven in the case of the NPN it was driven with respect to the ground because emitter was connected to the ground. Here the emitter is connected to the positive of the power supply. So, the drive is rail driven, but the circuit are exactly similar between emitter and the base have this resistor that is the positive supply and has its resistant between the emitter in the base even in the NPN circuit between base and emitter, you had a resistance.

But only now that resistance is connected to the positive rail and between the base and the signal source, you will have one more resistor and you have the collector flowing into the load as before in the case of the NPN of the collector was connected to the load.

So, you have this i c, the collector current which is the load current and let the transformer has the hFEsat some value i c by hFEsat will be just the saturation value. You have to provide i BON in the base drive. So, that it goes deep into saturation i BON is two times i c by hFEsat, so that value should be given here. R1 and R2 are the two resistances that you need to design and i BON is what you should give you.

So, how do you choose the value of R1 and R2? This is V besat like in the NPN circuit. R2 is given by V besat by unequal amount of i BON flows through like this. You have i BON flowing through in this fashion in this direction and Vcc minus this potential divided by R2 will be the current flowing through this and that current should be i BON two i BON will flow through R1.

Now, R2 let us calculate R2. R2 equals Vcc minus this potential is nothing, but V besat. So, V besat divided by i BON divided by i BON will be V besat into hFEsat divided by 2 times i c, same like in the case of an NPN drive circuit.

Now, if you have V b and V b is the signal voltage, so this will go low. When this goes low, then there will be a current i BON flowing from through R2 and i BON coming in from the base 2 i BON flows through R1 and sinks into the signal source. When V b is high when V b iis high, this potential will match the potential here and there will not be any flow of current in this direction. So, when V b is high, the BJT is of PNB BJT is off and when V b is low, the BJT is on ok.

So, let us say you have an i BON coming from here and i BON coming from here that will flow through R1 and that current will be 2 times i BON. Now, what is the value of R1? R1 is this potential minus this potential. What is this potential? This potential is Vcc minus V besat will be this potential. Let me write that down Vcc minus V besat minus V b that is the signal source potential will be the potential which is occurring across R1 divided by 2 times i BON will be R1.

So, i BON is nothing, but 2 i c by hFEsat. So, I will say hFEsat divided by 2 into 2 i c 4 i c. So, this will be the equation for finding out R1 in the case of the PNP drive. So, this is exactly the dual of the NPN drive and many a cases many complex drives are built from these two drives, NPN PNP complements because they complement each other and many stages can be achieved by this NPN PNP combination. We will of course have a look at this combination complimentary drives later.

The simple base drive circuit just two resistance in the base NPN and PNP base drive circuit are very popular and used in many base drive circuits. Let us see if we can apply them to our DC-DC converters. Now let us take the simple non isolated buck convertor. It is something like this.

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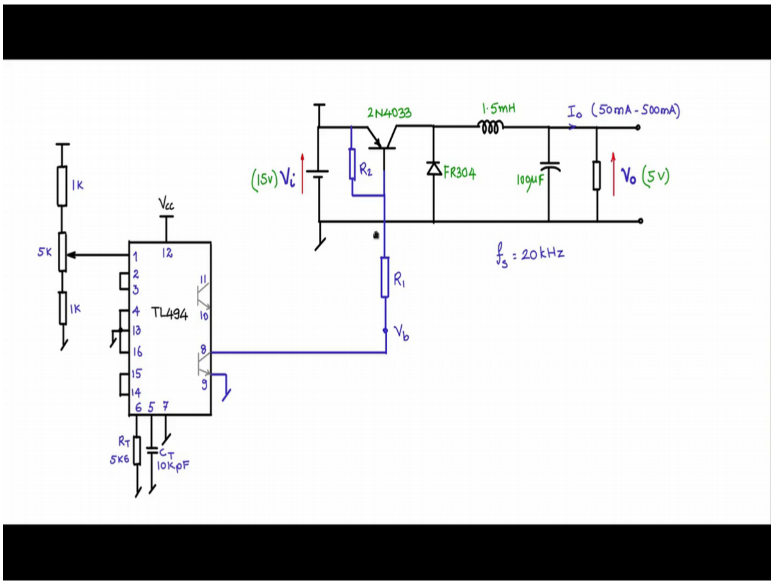

Now, here on the rail side on the positive side let me put a PNP transistor like this. If you are doing it on the ground side, you can use a NPN transistor. So, let me put this PNP transistor and let me complete this buck converter circuit by putting this diode, inductor, capacitance, resistance and then you are taking the output across these two terminal. This is V i and this V naught measured in these two fashions.

Now, for the PNP based drive circuit we just now saw from the emitter to the base let us put a resistor. This is a resistor from the emitter to the base and from the base to V b that is the source from where the signal is coming we put another resistor. So, this is our simple two resistor base drive for PNP which is driven from the rail. This is the positive, this is R1 this is R2 and this is V b.

Now, what to give here for V b? Let us see how we can give V b. In fact, to make this a practical circuit I can recommend that you try implementing this. It is possible you just take a 15 volts laboratory power supply. This will be your 15 volts input, you can design for 5 volts output, you can use 2N403 BJT transistor. This a PNP transistor easily available, then a diode you can use FR 304 diode easily available in common electronic shops, you can use a 1.5 milli henry inductor bound on a core you have to design and mind it on a core, put 100 micro farad capacitor and then that is it. You are having almost all the components and 4 I naught. You can design I naught again 5 milliamps to vary between 5 milli amps and 500 milli amps, max is 500 milli amps. So, the resistance here is known.

Now, what do we connect here and then at what frequency do you switch this BJT? So, let us put that down switching frequency of the BJT 20 kilo Hertz. So, almost everything is ready except that we need to give the pulse width modulated waveform here at V b.

So we had looked at how to generate pulse width modulation. Pulse width modulated waveform sometime back and I had also told you that there are commercial i c is available. One such i c's TL494 Texas instruments. TL494 vary inexpensive around 10 rupees or so. You should be able to buy that a new set.

So, let us make the connection 4TL494. Let us say pin 12 is Vcc pin and 7 is ground pin. Let me connect the ground and for the pin 12 ground. Ground means this, these two are joined together and this is Vcc. So, let us say this is Vcc and let me connect Vcc to V i. So, V i itself unregulated V i itself will be the power supply for the TL494 15 volts.

Next, I will connect two important components resistance timing resistance and a timing capacitance to pin 5 and 6. So, a timing resistance RT and a timing capacitance CT these are precision components use a metal film resistance here and use a metallised polyester capacitor for timing and if you want 20 kilo Hertz, you use one typical component value for resistance is 5.6 kilo ohms and the CT is 10 K p F. There are various other possibilities you can use from the datasheet. You can look at nomograph and pick up the values of RT and CT.

Next let me give something to vary the duty cycle. So, I will use a potentiometer and two resistances in this fashion resistance fixed resistance connected to Vc, fixed resistance connected to ground and in between I am having a potentiometer.

So, this is the variable resistance. It will this center tap will vary from a particular minimum resistance to a maximum resistance here and I will have a voltage here in between such that it is between the sawtooth. If you measure at pin 5, you will get a sawtooth waveforms, so, that the voltage here should be in between the sawtooth waveform.

So, connected in that fashion this we can say 1K 5K and 1K this connected to pin 1 pin 2 and 3. Now, 1 2 3 is an error amplifier pin 1 is the positive input and 2 is the minus input and 3 is output. So, you can sort 2 and 3 to make it in the voltage follower mode, there is also another amplifier which we can disable.

So, let us say 4, this is the duty DTC or the Dead Time Control pin. There is a staring pin and the other error amplifiers positive, all these let us ground it. We do not need it now, ground it and the plus of the other amplifier, the minus of other amplifier and the output of that one we sort it just like here in the emitter follower and the voltage follower mode.

Now, that is 15 and 14. Now internally there are two transistors that will get enabled or disabled depending upon the pulse width modulated waveform that is coming to the base internally of these internal transistors. So, this is pin 11 10 8 and 9. You can use any one of the transistors.

Now, let us say I use this 8 9, 8 is the collector, 9 is the emitter. Ground the emitter and the collector let me connect it here. So, that is it. You have pwm generator i c where the duty cycle can be varied and it is controlled and at this collector you will get pulse width modulated waveform which is given as get base drive signal to this PNP BJT which will switch this buck converter and you will get the required output. Now this is the open loop control of buck converter and is and it can operate as designed. R1 and R2 you know how to design it. Just we just saw while designing this PNP base drive.

So, how does it operate internally? When this internal transistor turns on, you will see that this will be shorting the collector will be connected to the emitter and the V b will be at ground potential ideally. So, there is a path for i BON to flow here and i BON to flow here to i BON flows through R1 into V b and into the ground and complete the circuit.

Now, let us say the internal enabling pulse is removed for the internal transistor. This is open. When this is open, pin 8 is floating. So, there is no chance of current flow through current i BON cannot flow, here BJT is off. So, in this way BJT can be turned on and off by controlling the internal enabling pulse to the internal transistor of the TL494.

But our focus here was just demonstrate to you how the base drive works. This is the simple base drive to resistance base drive and a PNP. If you put if we use the ground side switching you can use a NPN transistor and to resistor base drive. However, as you start going higher in power you will need more complex base drives and that is what we will look at further.