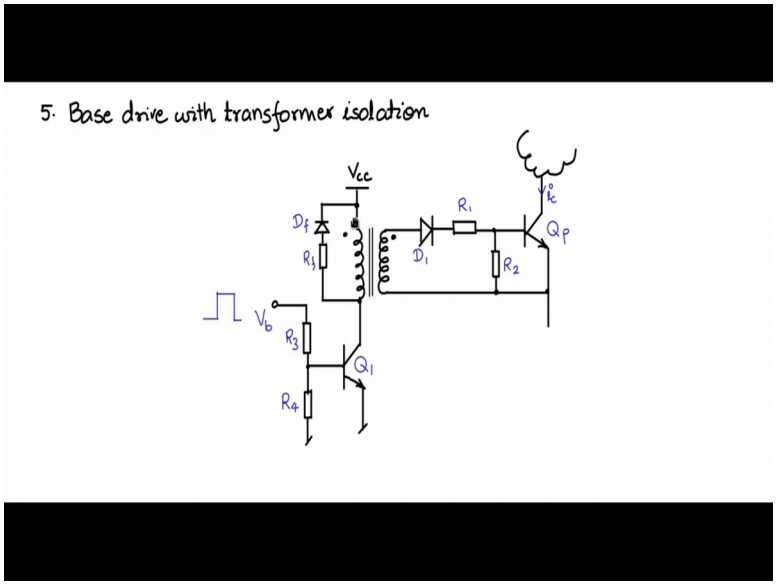
Fundamentals of Power Electronics
Prof. L. Umanand
Department of Electronics Systems Engineering
Indian Institute of Science, Bengaluru

Lecture – 85
Base drive with isolation

(Refer Slide Time: 00:27)



Let us now discuss a base drive circuit with transformer isolation. Let me begin by drawing an NPN transistor like this and I will drive this by a 2 resistor drive circuit. We are familiar with this kind of a 2 resistor drive circuit. We know this we know how it operates. In the collector of this NPN transistor I am going to place the primary of a coil transformer coil in this fashion call that as V cc.

On the same core the secondary coil also placed and look at the dot polarity whenever this is positive the dot on the secondary side is also positive, looks similar to the forward converter configuration. Now on the secondary side I will place a diode like this so, that I take only the positive signal and use that for driving the main power transistor.

So, let me draw the main power transistor which is supposed to be switched ON and OFF and this is the main NPN power transistor the collector is connected to an external load and the collector current there is what is supposed to be switched ON and OFF. So, we connect it like this and the drive for this is a 2 resistor drive, I will put a 2 resistor drive in this fashion yes.

So, this is the 2 resistor drive driving this one. We can now connect on the primary side a freewheeling circuit for freewheeling the magnetising current of the primary. Here you will give V b and V b will be the pulse wave form which will go high and low. So, when V b is low what happens, when V b is low you will see that Q 1 will be turned OFF.

I will call this 1 as Q p and this is i c which is supposed to be controlled name the parts R 1 R 2 D 1 this is R f and D f and R 3 and R 4. So, when V b is low there is no drive current flowing through R 3 therefore, no base current for Q 1 and Q 1 is OFF.

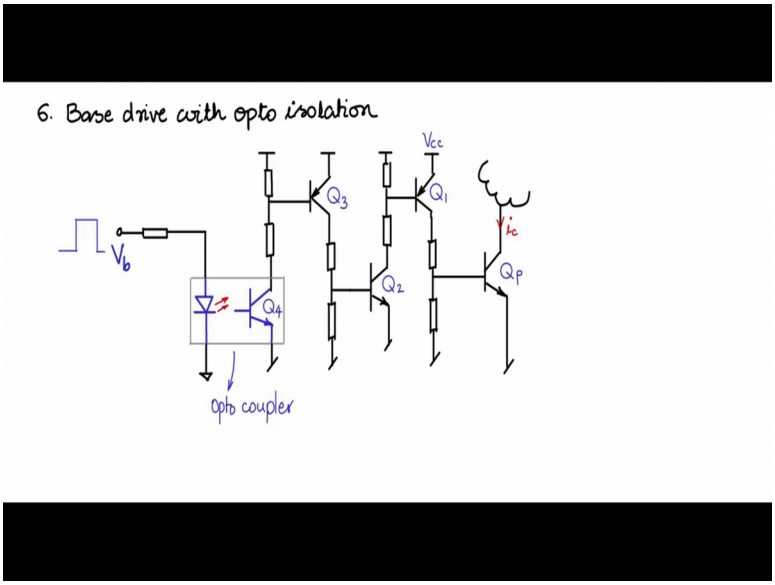
When Q 1 is OFF the voltage across the primary the dot is negative; the dot is negative the diode is going to be reversed biased OFF there is no current flowing through R 1, no base current to Q p; Q p is OFF. Now when V b goes positive high you have a drive current flowing through R 3 base current for Q 1; Q 1 is ON. Now when Q 1 is ON there is a current flow through the primary dot end is positive; dot end is positive, diode D 1 conducts.

So, there is a drive current R 1 through R 1 flows into base and turns ON Q p and Q p Q p is in the ON state and collector current flows. So, this way the Q p can be switched ON and OFF based on this signal V b through an isolation barrier. You see that the power side of the circuit does not have any physical connection to the control side of the circuit.

So, the control side of the circuit is isolated and the power side circuit is isolated. So, there is some degree of protection for any spikes and surges coming on the power side where we will not get, it will not get transferred on to the control side and protect the control side circuits. So, this is a transformer isolated based drive circuit. The operation of this transformer portion using Q 1 as a switch is very similar to that lie that of a lossy forward converter.

So, by that same argument you can convert this lossy forward converter into a loss less converter, loss less based drive circuit by putting one more coil 1 is to 1 with dot polarity inverter like in a lossless forward converter and put a diode here and then put back the magnetising energy into the supply can do that one however, that I will live you to live it to you for doing that and understanding how that works.

(Refer Slide Time: 05:45)



Let me now discuss another based drive isolated based drive, but instead of transformer isolation I am going to discuss opto coupler isolation; opto or the light isolation. So, let me start by drawing now here this is the power transistor Q p and that is connected to the external load the collector current of which we need to switch ON and OFF.

The drive for this Q p is coming from a 2 resistor combination we know how this works and in order to reduce the drive current from ultimately the V b source, let us put in multiple stages. So, there is a PNP stage here and the PNP stage we know how to drive that by 2 resistor combination in this fashion. This is connected to an another NPN stage, the NPN stage I am going to drive by another 2 resistor combination.

And this is being driven by PNP stage and the PNP stage is driven by another 2 resistor combination, like this you can keep going. Now let us say at this point normally we would collect connect V b that is the base drive signal, but we need isolation. So, in order to provide isolation I am going to connect another device which is actually a b BJT, but driven not by current, but by light generated from a photo diode.

So, this whole photo diode combined with this transistor this whole device is called an opto coupler. So, that transistor which is the opto coupler transistor I am going to connect here and ground this. So, this will be the drive transistor for this base drive. However, the drive for this is coming from light and the light source being obtained whenever there is a current flow through the diode.

So, the diode is now connected to another ground another circuit ground totally physically different from the power side ground. So, there is a resistance here and V b and to V b there is a pulse in this fashion. When V b is low there is no current flowing through this resistance and the diode and as there is no current flowing through the diode there is no light source and therefore, the transistor of the opto coupler is OFF. When V b is high there is a current flow through this diode and the transistor of the opto coupler is on. So, that is how this opto coupler operates.

Let us first name the parts. So, here is i c this is the current that you need to control switch ON and OFF, this is V c c let us call this Q p power transistor to be switched ON and OFF. Q 1 this PNP transistor, Q 2 NPN transistor, Q 3 another PNP transistor, Q 4 opto coupler NPN transistor ; now this is the opto coupler right.

So, let us see the operation let us say V b is low there is no current flowing through the diode; the diode does not emit any photons the Q 4 is OFF because Q 4 is OFF there is no drive here there is no base current for Q 3; Q 3 is OFF and Q 3 is OFF there is no drive here, there is no base for Q 2. Therefore, Q 2 is off; Q 2 is OFF there is no drive here, no base current for Q 1; Q 1 is OFF Q for Q 1 is OFF there is no base drive for Q p; Q p is OFF i c is 0. Now when V b is high here; when V b is high there is a current flow in this circuit limited by this resistor.

So, the diode once there is a current flow m h photons and the Q 4 is turned ON Q 4 is driven and it is turned ON; once Q 4 is ON there is a current flow through this resistor. So, there will be i b ON and an i b ON from here to i b ON will flow through here Q 3 will be ON when Q 3 is ON there is a drive current flowing through this path into the base of Q 2; Q 2 is ON.

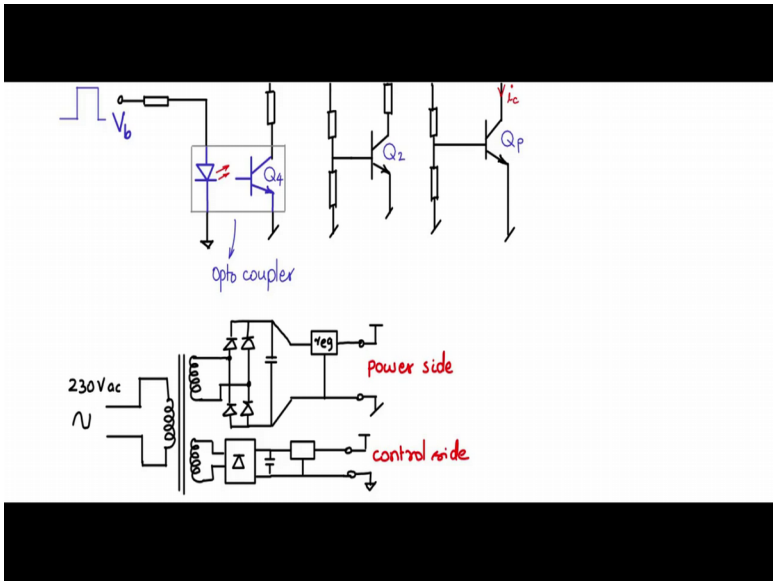
When Q 2 is ON there is a drive current flowing from the base of Q 1 into this and then there is current flowing through in this fashion Q 1 is ON. When Q 1 is ON you have a drive current flowing into the base of Q p and Q p is ON and i c flows. So, in this way Q p can be turned ON and OFF by this base drive signal.

See the number of stages. So, the current here will be i b ON 2 i c by h f e sat and then you have here 4 i c by a h f e sat then divided by the h f e of Q 1 will come in here and divided by the h f e of Q 2 will come in here divided by h f e of Q 3. So, this will be a

very small current and opto couplers normally available or generally handling currents in the order of milliamps.

So, you reduce the drive current to low value by this multiple stages interpose this opto coupler; the opto coupler gives at least 3000 volts isolation between this part of the circuit and this part of the circuit and this is a very good isolating base drive. Now, note this different grounds here how do you give the power supply for the power portion how do you give the power supply for the base portion?

(Refer Slide Time: 12:21)



Recall that we studied during the rectifier when we studied the rectifier, how to generate power supply multiple power supplies isolated? So, just let me show that you have 230 volts a c and let me say you have a transformer step down transformer and you have 2 secondarys. So, in one of the secondarys let us say have this rectifier diode we know how this circuit operates put the capacitor filter. To the output of the capacitor filter connect a linear regulator and the output of the linear regulator you will get a regulator supply.

Now, this let us mark this is a V c c and this will be let us say this ground the power ground. So, this portion of the winding you can use it for the power side here across V c c and this ground. So, that will be the power side supply. Now the other winding, so, the other winding you can pass it through a similar rectifier just like I have shown here bridge rectifier I am showing it like a block.

The output of that bridge rectifier you can have a capacitor filter like this and the output of the capacitor filter can be passed through a 3 terminal regulator and that regulator output can be used for the control side that is worth this power supply in ground, look at this ground symbol. So, I can use that ground symbol another power supply which can be given to the control side.

So, this portion I will give it to the power side and this supply I will give it to the control side. So, you see that this power supplies themselves or isolated there is no physical contact with 230 there is no physical contact between the power side and the control side in terms of the power supply. And there is no physical contact between the control side and the power side because of a through that drive because of the opto coupler.

So, there is a at least a 3000 volt isolation between the power side and the control side here and there is also around 3000 plus 3000 volt plus isolation between the 2 secondary's. So, the power side and the control side are totally isolated.

As compared to the transformer isolated base drive, transformer isolated base drive very simple there is no need for secondary side power supply, it is just like a forward converter you have 1 power supply here and then the secondary side the power transformer is of a power transfer is occurring through the transformer. So, the base drive is base drive power is coming right through that transformer and turning the switch ON and OFF.

Whereas, in the case of the opto isolated base drive, you need a power supply on the secondary side of the opto coupler and therefore, you need to have an arrangement like this where you are having dual power supply, 1 power supply isolated given to the secondary side of the opto coupler and another power supply given to the control portion of the opto coupler. Only then the isolated galvanic isolation is achieved and isolated base drive well work with sufficient voltage isolation between the power and the control portion.