Fundamentals of Power Electronics
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Lecture – 87
MOSFET drive with isolation

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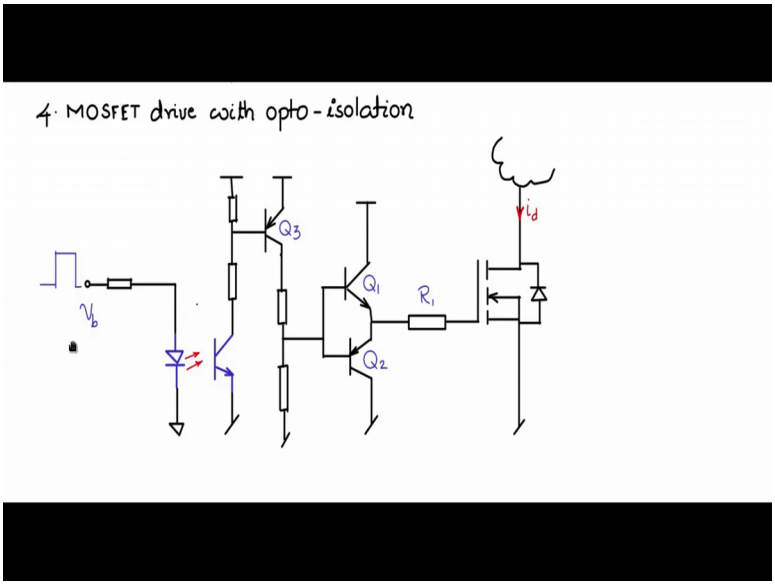

Like you had isolated base drive for the BJT, where the power side and the control side were physically isolated galvanically isolated. Even in the case of the MOSFET we can have galvanically isolated gate drive circuit. Now we saw the BJT gate drive BJT base gate drive circuit where the MOSFET is driven by this Q 1 Q 2 totem pole BJTs which is driven by Q 3 and which was driven by an NPN stage.

Now, this NPN stage I will replace it with the NPN BJT of an opto coupler, the opto coupler where this transistor is being driven by the light emitted from a photo diode. So, let me ground this and then connect the pulse source to this opto coupler diode in this fashion and we have V b the pulse source here. So, observe here when V b is 0 there is no drive current to the opto coupler diode current is not there diode will not emit photons and the opto coupler transistor is OFF. So, when this is OFF there is no drive current here Q 3 is OFF.

When Q 3 is OFF there is no drive in this path and therefore, Q 1 is OFF when Q 1 is OFF there is no drive to charge up the capacitance of the MOSFET and therefore, the

MOSFET is off. So, when V b is low MOSFET is OFF. When V b is high there is a drive current flowing through the diode in the diode emits light and the opto coupler transistor is ON there is a drive current here Q 3 is on.

Q 3 allows drive current to flow through in this path to Q 1; Q 1 is ON and Q 1 is ON there is a drive current to charge up the capacitance of the MOSFET and the MOSFET turns ON. When you want to switch OFF the MOSFET, you are switching OFF the pulse here goes low, this is OFF this is OFF Q 3 is OFF Q 1 is OFF, but there is a charge ON the capacitor here plus minus.

So, that is coming to this point emitter of Q 2 the base of Q 2 is low and because emitter of Q 2 is positive Q 2 will turn ON and because Q 2 turns ON there is a reverse current flow in this fashion and discharges the gate charge capacitance. So, this is the discharge path and turns OFF the MOSFET.

So, this is an isolated gate drive circuit for the MOSFET, remember the power side or having different grounds the control side is having a different ground and just like in the case of the BJT you need to have a power supply with isolated secondary windings and one winding is used for generating the power supply for the power side and another winding is used for generating the power supply for the control side. So, in that way total isolation galvanic isolation is maintained between the power side and the control side and the opto coupler gives an isolation of 3000 volts between the 2 sides.

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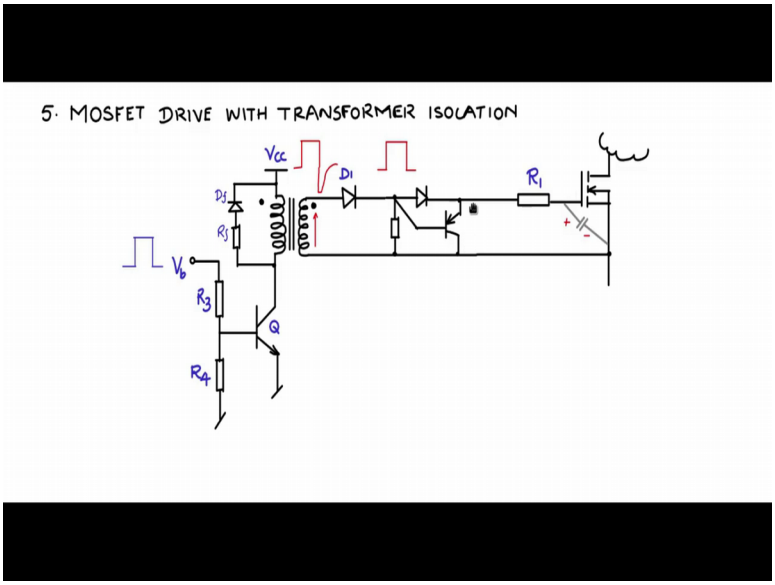

Like in the case of the BJT base drive we discussed with transformer isolation, the MOSFET base drive can also be done with transformer isolation similar circuit let me draw that. So, the primary of the transformer is connected to an NPN transistor and the NPN transistor is driven by a 2 resistor drive which we are familiar with this fashion. Observe this is NPN transistor which I am using here can also be done with replaced with the MOSFET.

Now, the secondary of the transformer is passed through a diode like in the case of the BJT drive and it is connected to the power MOSFET. The power MOSFET is connected in this fashion drain connect to the external load source is connected to some other point in the power circuit. The transformer non dot end is connected to the source and the dot end to the diode and the diode is connected in series with the resistor in this fashion.

So, this will be a 1 resistor drive for the MOSFET. Let us name the parts is R 1 this is D 1 V c c Q R 3 R 4 and this is V b the base drive pulse given at this point. So, when the base drive pulse V b is high. So, you will have a current flow through R 3 there will be a base drive current for Q; Q will be on.

When Q is ON the transformer primary is active with dot end positive; dot end positive means ON the secondary side dot end positive and there will be a drive current flowing through D 1 R 1 to charge up the MOSFET and the MOSFET will turn ON. So, as long as dot end is positive the MOSFET will be ON.

Now, when V b goes low there will not be drive current through R 3 Q is OFF and here the dot end becomes negative non dot end becomes positive the diode will be reversed biased and it will click the wave form. However, the MOSFET has MOSFET capacitance that there is no discharge path for the MOSFET capacitance. So, it will not turn OFF. So, you have to provide a discharge path for the MOSFET so, therefore, we will put a resistance here R 2.

Only then now the MOSFET can turn OFF there is a discharge path. Also node on the primary side we will put a diode resistor combination like this the freewheeling diode in the freewheeling resistor this is necessary to demagnetise the core. So, that it is ready to operate in the next cycle. So, this is the transformer isolated drive for the MOSFET.

In the transformer isolated gate drive shown here there is not much control in speeding up for the turn OFF of the device because the presence of R 2. You cannot make R 2 too low because is the R 2 is made too low while turning ON R 1 R 2 becomes an attenuator. So, if you are applying 15 volts here, you can have a very low voltage applied at the GATE; gate source and the MOSFET may not go into full enhancement it may be in the linear region.

Therefore, it is better to replace R 2 and have an active pull down to speed up the turn OFF process. So, let us do that modification. So, I will remove this make some space and connect it here and here, I will put an active pull down circuit. So, let me use a diode and a PNP transistor in this fashion, I will put a resistor here and connect the base to this point and let us see how this operates.

Now, here there is an internal capacitance remember. So, we will have the gate source capacitance indicated by this grade line here. Now, when let us look at the wave form at the secondary when V b is having a pulse wave shape and the in this fashion whenever V b is low Q is OFF and whenever V b is high Q is ON. So, let us say V b is high Q is ON dot is positive dot here will be positive. So, you will have a wave shape something like that and then when here V b goes low Q turns off.

So, when Q turns OFF there is a freewheeling action happening here. So, the voltage exponentially will start coming down, so, negative will, it will go negative and start exponentially coming down. Remember that this area positive area negative area should always balance out volt second balance is always valid. So, you will have a wave shape like this going negative, that is why we have put this diode D 1 and on this side the diode will clip it and will give you a nice neat positive only the positive pulse.

So, during the time when it is positive there is a current flow like this and this second diode that we have put will have a polarity plus minus forward drop of 0.6 in this fashion. So, there is a current flow and it will flow through R 1 and charge up the CGS capacitance. So, a charge of QGS is deposited in the MOSFET and the MOSFET will turn ON. So, during that time when you are driving the MOSFET on diode is plus minus in this fashion look at the PNP transistor emitter is minus base is plus.

So, this transistor is off, so, it is out of the picture. Now after this is ON and then you decide to switch OFF the MOSFET you bring V b low. So, when V b is low you are in

this portion of the region where is in this portion of the region of the pulse. So, let us say that at this point capacitance is fully charged to V c whatever this peak value V c c value and diode is now not conducting. This capacitance potential appears here emitter is positive this is at 0 potential with respect to this there is no current flow.

So, therefore, there is a possibility of base drive to flow in this fashion. So, emitter is positive because of the capacitor. So, you will have a base drive flowing in this fashion here, it cannot go in this direction because the diode. So, it has to come in this direction and complete the circuit. So, if the base drive flows then the transistor Q can be ON and you can have a larger collector current flow in this fashion and discharge the capacitor.

So, the capacitor in fact, the charge GATE; gate source capacitor, in fact, mix this active pull down work. So, this is a much better circuit much faster turn OFF can be achieved with this.