Fundamentals of Power Electronics
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Lecture – 88
Over-current protection

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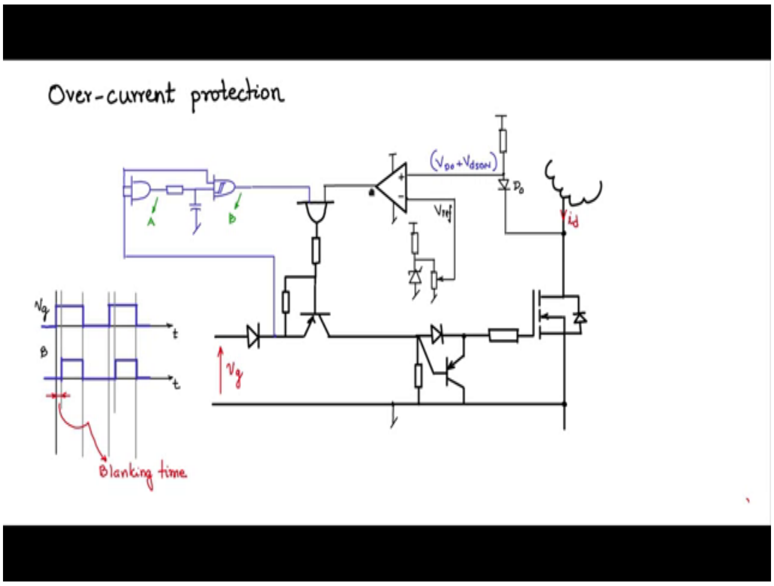

Let us now discuss about the current protection for the MOSFET and the BJTs. Though I will be describing this current protection scheme with respect to the MOSFET power switch, it is applicable even to the BJT power switch. So, let me first draw the MOSFET power switch like this you have the gate, you have the drain connected to an external load and the source and there is an internal body diode.

So, this is the MOSFET it has a one resistor drive single resistor drive as shown and there is an active pull down, active PNP pull down as we discussed there is a diode here. And I am going to put a resistance here and the base connected to this point. So, this is the active pull down that we discussed and we have a diode here. So, this part can be isolated or non isolated, but this is essentially the drive part which is there just before the power MOSFET.

Now, how do we go about doing current protection, we have here the drain current and we need to we need to do some action if the drain current exceeds the rating as particular set limit. So, if there is an over current then this drive must be switched off the MOSFET must be switched off even if the drive current the gate drive is present.

So, how do we do that? The principle that we are going to use is that as the current increases the voltage V d s across the MOSFET or VCE across the BJT is going to increase. The voltage across the device is going to increase. Now we have to detect this increase set a set point and once the increase goes beyond a particular value, then we say that over current has happened and we will switch off the MOSFET. So, that is the principle that we are going to take.

So, let us do some modifications to the circuit here, I am going to push the diode back here and I am going to put a series pass a series switch I am going to put a series PNP switch here and this PNP switch is having a two resistor drive which we know how it operates. So, if this point here is high if the voltage is high then there is no current flowing in this resistor.

And therefore, no base current flowing up and therefore, this series pass switch is off and the drive is cut off the capacitance will discharge and the MOSFET will switch off. Now if this point here potential is low, then there is possibility of current to flow through like that, there is a possibility of current to flow through like that, and there will be a base drive and this switch will be on. .

So, now this is a series pass switch we will operate. Next let me put an Op-amp comparator Op-amp high flew rate comparator Op-amp plus minus it has its power supply its a unipolar power supply Op-amp and to the op amp minus I will give a reference how do I generate a reference I will have the resistor Zener; Zener diode and then potentiometer across this is a typical shunt regulator which we have discussed some time ago. So, this output I will give it to the minus, I will adjust the pot value here such that I have some V ref value this is the reference value. If the positive value goes above, the reference value this will be high. Now, let this plus terminal be connected to the over current detection circuit. So, how do I detect over current?

Now, I will put a resistor a diode and then connect it in this fashion. So, this point now this is the ground here for this circuit, the power supply here is obtained from. The secondary of an isolated transformer and the power supply is specifically for this gate drive circuit. So, it is isolated now this is the ground, now from this point I am going to tap off and connect it to v plus.

What is this potential? When the MOSFET is on there is a drop across that I will say V d s ON. V d s ON is coming across that this diode is conducting in this fashion to the ground from the power supply there is a current flowing through this diode through the on device and to the ground. So, therefore, this potential will be diode drop plus V d s ON drop we will just write that down. So, we have V D, V D 0 forward drop plus V d s ON. So, this will be the potential here

So, V D 0 is around 0.6 0.7 volts and this is the V d s drop and as the current increases the MOSFET has an on resistance RDS on. So, or RDS on into i d will be the drop across this and as i d increases the RDS on i d drop across this increases V d s ON increases and this will increase. Beyond a particular reference value set point value this will go high the output will go high and that if I am connecting it here when the output goes high.

This point is high and this PNP transistor is switched off and once this is switched off there is no drive to the MOSFET, the MOSFET will discharge through this PNP transistor in this fashion and this will turn off. So, whenever there is a over current V d s ON is acting as the sensor for the over current and that will shoot up and that will go beyond the reference value, and it will make the output of the op amp comparator O p amp go high and switch off this series switch element and cut off the drive. So, this is the principle on which the over current protection comes into the picture. However, there is a small problem in this.

When the MOSFET is off; when the MOSFET is off the voltage across D and S is a very large voltage as dictated by the external circuit because, when the MOSFET in the off state it is going to withstand the entire V d c link voltage, which may be a very high voltage value. Now, once that is a large value V d s during the off state V d s during off state plus V D 0 will be coming at this point and therefore, this would always be high and this will be disabled. So, you will not be able to turn even if I give a turn on pulse you will not be able to pass the drive on to the gate of the MOSFET because this is always off.

So, you have to provide a small period of time when you want to turn on a small period of time when this is disabled means this is on, it should allow the MOSFET to switch on turn on V d s should come low to the on state; and it is the V d s ON that we are interested the fluctuation and the variation in V d s ON during the on time and the i d can vary depending on the external load. So, allow it turn on and then enable this part of the circuit. So, that is what we will be doing slight modification in the circuit.

So, let me use an AND gate and the input AND gate I will pick it off from this point this is the gate pulse itself. So, the gate pulse comes in here now the gate pulse from the output of the AND gate is passed to an RC filter. So, this is an RC filter and as this an analog signal I will pass it through a Schmidt and so this is going to rise slowly the other input of the Schmidt and I will give it directly.

So, this is going to rise immediately it is going to fall over the gate signal this is going to rise slowly. So, which means a delayed gate signal and the output is going to be delayed by as by sometime as dictated by this time constant. Now the output of this I will call this A and I will call this B the output of this and this should be ANDed and given here. So, how does this operate? So, whenever there is a gate pulse this circuit will delay the enabling of this means this will be low for some time where a small amount of time turn on time during that time this is low.

So, even if this is high the output of the and gate is low therefore, the PNP transistor is enabled this is going to cause the drive to flow through to the MOSFET a charge is put and the MOSFET turns on after the MOSFET has turned on you need to enable this portion of the circuit. So, this will go high, this will be enabled and this will go low because when V d s has turned on and the current is within the limits this will be low and this PNP will be on as long as there is no over current and this have this is low.

Once there is an over current this v plus will go high output of the O p amp will go high and this is already enabled from here therefore, this AND gate output will go high and disable the transistor. So, this operation is very important let me say that this is v g let me just indicate how this delay action comes in, let us say v g is like this, this is the v g signal gate signal that you are going to give v g look at v b here the point B how the signal comes.

Now, see v g is coming directly to this Schmidt AND; and the other input the Schmidt and is coming through an RC. So, this is delayed signal. So, therefore, output here will be delayed by a small amount of time as we decide by the RC time constant. Now because it is delayed here the AND gate output is low for a small period of time here.

And this is the enabling that this is called the blanking time and it is during this blanking time why we say blanking time? The current protection unit is blanked out at that time; and PNP transistor is on. So, during that time the MOSFET turns on and V d s becomes low and goes into V d s ON mode at which time V d s chi if the current is within limits this will be low. So, if this is low then even if this is high the output of this AND gate is lower and the PNP is on.

So, it goes high after a small amount of time which means this will become the enabling pulse for this after a small amount of time and then after that any fault that occurs here will disable this PNP and switch off the drive and turn off the MOSFET. So, this is how over current protection operates and this is one of the most popular over current protection circuit which is used in almost all the i cs gate drive i cs. The current protection most the gate drive i cs uses this principle.