Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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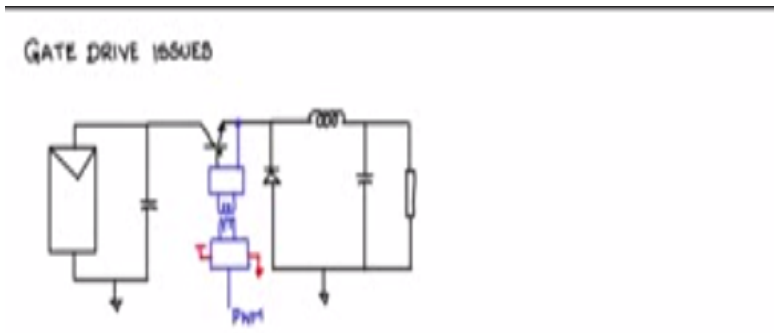

Let me now point out to you some practical point with regard to gate drives. Gate drive of the power semiconductor switches of the DC-DC convertor which is interfacing the PV source to the load or not. Consider the pre module and the DC-DC convertor, I am going write right now about convertor. It could be any other converter which you are using for the application.

Now these two points are the same points and this is the switch. So normally I have been denoting the power semiconductor switch as a BJT with the gate line sticking out the gate pin, sticking out like this. But actually this itself along with the drive is a quite an involved circuit. Now consider for example this ND and transistor. The base drive is given with respect to the emitter.

Now it was a mass fit the gate drive would have been given with respect to the source. Wherever are we used BJTs bipolar junction transistors you can use masters even IGBTs. Now this BJT is driven by a gate drive circuit and that is referral with respect to the emitter.

The drive is given to the base with respect to the emitter, because this emitter point, is connected to a node which is varying in potential.

So I had some instant of time in the drive is conducting this is zero, some instant of the time when the powers which is conducting this is at VT, and therefore, this potential being not fixed. You need to see that this gate drive is reference with respect to the emitter only and this portion of the drive is isolated from the portion of the circuit which is reference with respect to this circuit graft.

So therefore, you lead an isolation and circuit that appropriately drives the PWM signal into the gate. Now this portion of the circuit drive will have a power supply which is referenced in such a way that they are caught. Now let me show you an example of this portion of the circuit this isolated gate drive driving a BJT and also probably a mass fit.

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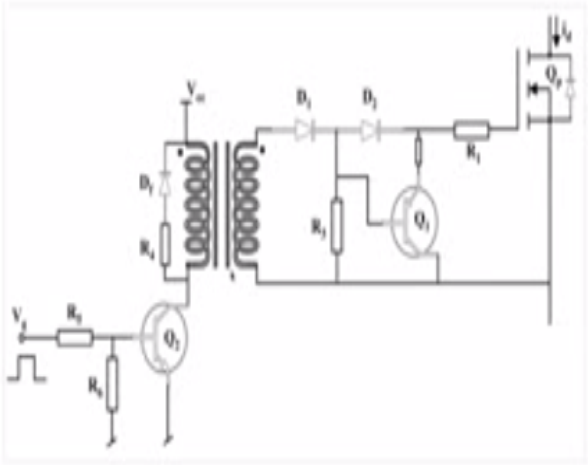

This is a sample circuit of an isolated gate drive circuit, it is transformer isolated you see the transformer here. This QP is the our BJT through which the power current flows through, the rest are all gate drive circuit, this portion of the gate drive circuit is in the second of the transformer, this portion of the gate drive circuit of the primary transformer. Now consider this point, this is the input point connection in the PWM block which probably may be within a PWM IC or for coming from an IO port of micro controller.

Now this when this goes high VB was high there is dry for the base of Q2 and Q2 will go on to saturation R5 and R6 also designed that Q2 will saturate and this point, this where I am indicating by the mouse cursor will get connected to ground. In the whole VCC will appear

across the primary winding with dot as positive. This portion is out of the circuit because of the diode.

Now this side dot also will be positive, this will forward by this diode will forward by this diode. When this diode is forward by as + - Q1 is assure to be off, because the PNP transistor. And it flows through R1 into the base of QP and terms on QP. R2C is basically as speed up circuit when this terms on C will be a short for turned on R2 is very small compared to R1 very large, such current flows through it and speeds of the terminal process of QP.

If this portion is not there even then it will work, but it will be with slower turn on. Now when this goes slow, VB go slow, Q2 will go off. The base charges will recombine in this pass through R6 and if the turns off, there will be reversal of the polarity, this becomes negative, this becomes positive, and magnetic energy will free wheel through this. So likewise here this got will be negative with respect of this which is positive and this diode D1 will be reverse bias on out of the picture.

This base is connected to its collected through R3, so the potential AR is zero. This potential AR because of the capacitance will be positive. It will drive Q1 on and there is a recombination base current that will flow through in turn of QP. So this is how this particular based drive isolated base drive will work. Of course you could replace this with the mass fit 2.

This is the same base drive which has been converted into a gate drive, because it is now driving the gate of the mass fit. So this is the end channel mass fit, so this is the drained, this is the gate, and this is the source and the gate drive is given with respect to the source of the mass fit. Circuit is similar to what we saw for the BJT only have removed the speed up resistance and capacitors of the speed up circuit is removed.

The reason is that there is capacitance between the gate and the source inherently within the mass fit and that will act as a speed up circuit. So when VG goes high, VG is currently from the PWM block of PWM IC or IO port of a micro controller and when VG goes high, Q2 is on. This is connected to ground the entire VC at this across the primary. positive. positive diodes are forward by us, diode D1 and D2.

And then it flows through R1 and capacitor is a short during at time enables such current of flow through it and then quickly charges of the capacitor. Therefore the gate source voltage builds up and turns on QP. Now when this goes slow VG goes slow, Q2 goes off. There is

the reversal of polarity it free wheels throughout for NDF the magnetic energy. This dot here also is negative with respect to the other N diode D1 is off.

And this R3 is connected to the ground here and then D2 is off and you will see this capacitor gate source capacitor will discharge through Q1 in this fashion. So in this way the mass fit gate drive circuit isolated gate drive circuit also works similarly. Instead of transformer isolation instead of magnetic isolation in literature you will find optocoupler isolation to let me show you an optocoupler isolation example.

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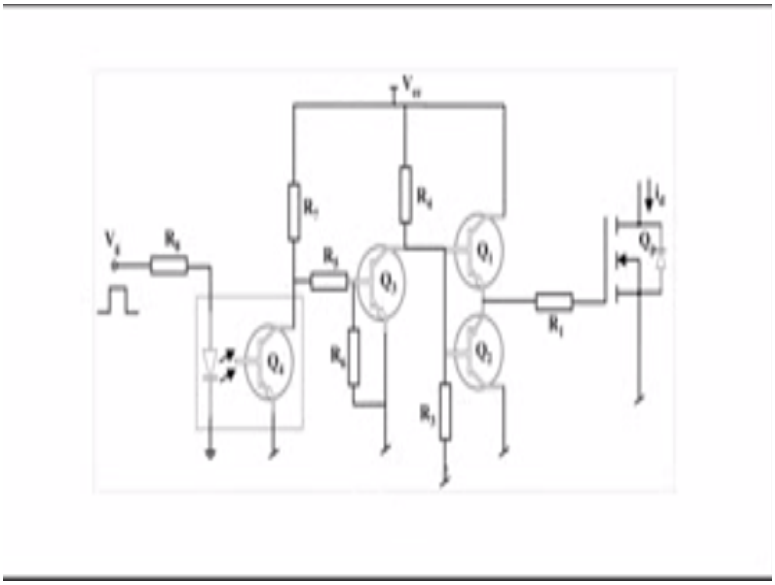

Here is an example of an optocoupler isolation. See here this is an optocoupler. It consists of a diode on the primary side and draw circuit 4 as you see here on the secondary side. The transistor is trigged by the light emitted by the diode. So now let us say when VG goes high, VG connect from the PWM block goes high. There is current flow through this diode, it emits light and triggers Q4 and Q4 goes on and this is connected to the ground.

So this potential here will be grounded and because of that Q3 will not get base drive and Q3 will be off. So if Q3 is off this point here as I am showing the mouse cursor, the mouse pointer will be high, because VCC will come to this point and there will be base drive for Q1, Q1 is NPN, Q2 is PNP. There will be base drive for Q1 not for Q2 and therefore, Q1 will be on.

Therefore from VCC is like this, in this part current flow charge up the gate or source capacitance of QP and turn on QP. So when VG goes high, QP will turn on. When VG goes slow, there would not be current flow in the diode, no light source and therefore, Q4 will be

off. This potential here will be high, there will be base drive through R7, R5 into Q3, Q3 will be on and the collector of Q3 will be low, because Q3 is on.

Thus will be grounded and Q1 will be in the off condition. Now during that condition, the potential across the gate source capacitance will drive Q2 and discharge through Q2 in this fashion. So that way QP will turn on. So this is an example of an optocoupled gate drive using mass fit. You could have an optocoupled gate drive for the transistor BJT also.

One important think that you should notice is that on the primary side all this circuits will have a power supply with reference to this ground. I will show it in this symbol form. And on the secondary side also there is a power supply requirement unlike the transformer isolated gate drive. In the transformer isolated gate drive the power is transferred there is no need for a power supply in the secondary side, but in an optocoupled isolation only the information is transferred.

You need to have a power supply in the secondary side also, that which is isolated and different from what is on the primary side. So that extra circuitry is needed then only this portion of the drive will work.

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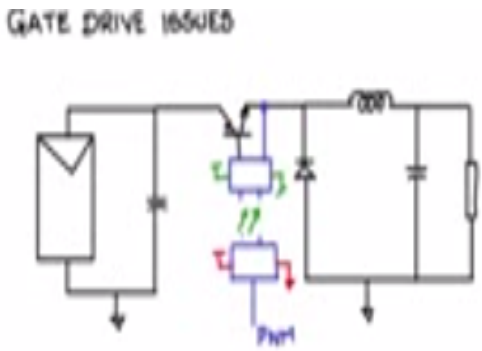

So if you consider this and remove the transformer isolation and I have light source how this becomes an opto isolated gate drive. This portion of the circuit needs as separate power supply an indicating this and this ground and this ground are separate and different. So these are isolated supplies only then it will work. Alternately, if we need to main the gate drive

simpler especially for low power circuits we can replace the NPN BJT with the PNP BJT what happens.

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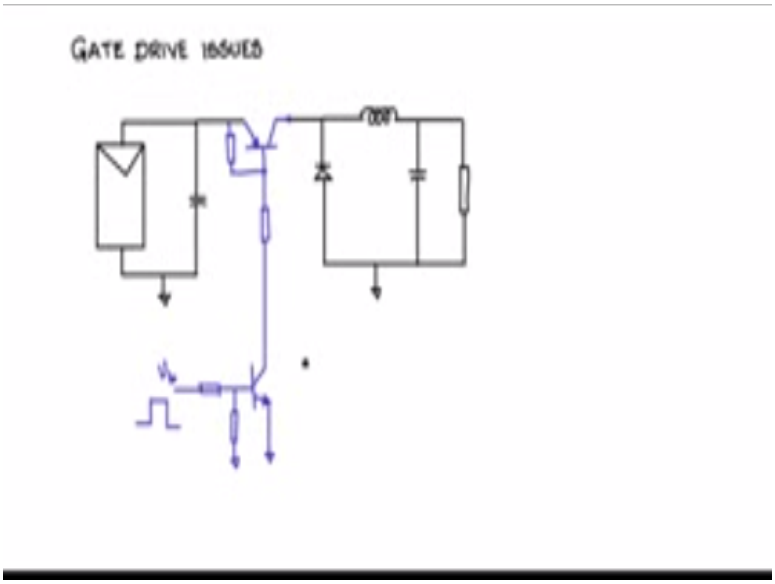

So let me erase this portion or remove this portion and let me include PNP BJT there bipolar junction transistor. Now because it is PNP the emitter is connected to VT. VT is not a varying node potential has this point here on the other side. So this emitter and the base can now be used for driving this transistor. Now let me connect the register between the emitter and the base.

And then connector register like this and then that to the connector of a NPN transistor, and I will have the base of this NPN transistor connected in this fashion. And let me give the PWM signal to VB here. So it has become as much simple base drive circuit with the same grounds, so you see that VB when give the signal when VB goes high. These two resistance are so designed that there is enough base current of flow through this transistor.

This transistor turns on which means this point gets connected to ground. So if this point gets connected to ground there is a flow of current in this fashion and there will also be a flow of current through this base, because when there is a flow of current through this is positive, negative and there is a point 6 volt drop you will see current flow in this fashion also, and these two values of the resistance are properly designed, this PNP transistor go on.

So that will turn on and when this goes slow this will, there would not be base drive for this transistor, this will go off. There is no base current flow, chance for base current to flow this will turn off. But there will be base current recombination path here, so in this way this simple base drive circuit can be used for very low power applications, because you will not find PNP for very high or applications and pass which in applications.

And if you want to replace with the mass fit, you can use the P channel mass fit with the same principle. If the power levels go high and you need to use NPN transistors, because the PNP transistor and P channel mass fits or not available for higher powers.

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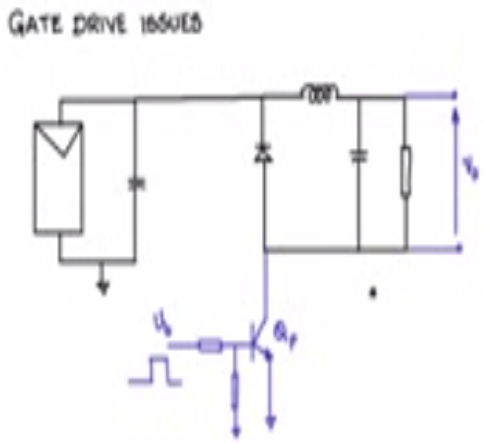

In that case there is yet another simple way to have a simple base or gate drive circuit, what we can do is okay erase this portion let me joint the portion there, and I will remove this ground here and place on NPN transistor here. I can use NPN transistor or N channel mass fit there. And I will drive the base of that transistor in this fashion and I will get the PWM signal to VB from the PWM block coming from a micro control are PWM IC.

You see this is a simple circuit and you tend the output across R0 in this fashion. So here the load potential you will see that the load ground is different from the source ground. Of course in this case the PB panel being are isolated component you do not need to how this source ground and the load ground same. It can be different and therefore, it is permissible to how the load floating.

So operation sample when VB goes high QP turns on, so when QP turns on this is connected to the ground here and then there is a flow of current through the inductor, capacitor load, and then through this into this ground like this. And when this goes slow, QP goes off, there is only freewheeling action there is happening here this is open. So this operation can also be used this will give you pretty simple drive circuit for driving the power switch on and off.

I will now show you a simple circuit diagram with the simple base drive circuit which you can quickly break it up and implement in the lab.

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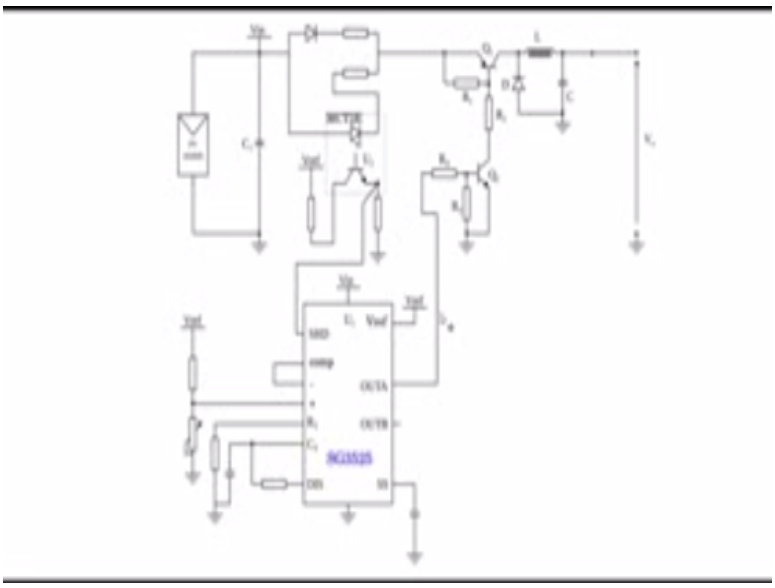

So this is a complete circuit which contain the PV module which is connected to capacitor C, and the power flows into this portion of the circuit. Recognize this portion of the circuit, there is a PNP switch followed by buck, so this is a buck circuit, buck related circuit and I will use PNP here and then using R1 and R2 to drive this Q1 and Q2 just we discussed this type of base drive circuit.

And then the PWM signal is coming from an IC SG3 525, it is a PWM IC. And you can set the voltage you can set the duty cycle of the signal that you are getting here by adjusting this voltage by through this spot. Now there is a shutdown pin here it is coming from this portion

of the circuit, where is an out block of MCT to EET is operated in the linear region here. I am having a double branch diode resistor and optocoupler diode in the resistor, these two resistance are known.

Therefore the current flowing through this optocoupler diode is a measure the total current which can be used for sensing that and protecting against any over loads. So this diode will emit the light proportional to the current and the transistor portion will have pass a linear resistor variable resistor and accordingly to the potential here will change and that can be sensed and used as a current protection circuit and used for shutting down the PWM IC. So this is a simple circuit, very simple circuit that can be easily implemented in the laboratory.