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How to Select MOSFET Drive Resistor?

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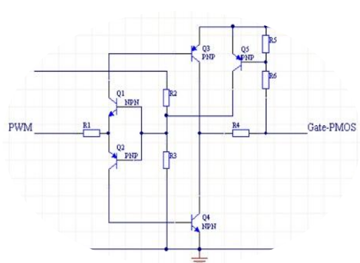

The larger the resistance of the drive, the longer the turn-on time of MOSFET, and the longer the voltage and current overlap time in the switching time, the greater the switching loss. Therefore, the smaller the resistance, the better the drive resistance should be, provided that the drive resistance can provide enough damping to prevent the drive-current oscillation.

When designing switch power supply or motor drive circuit with MOSFET, the factors such as on resistance, maximum voltage and maximum current of MOSFET should be considered. In general, the MOSFET tube can be divided into the enhanced and depleted, P-channel or N-channel is a total of 4 types, but the enhanced NMOS tube and PMOS tube are mainly used, in these two commonly mentioned enhanced type, the more commonly used is NMOS, The reason is its small on-resistance and easy to manufacture. However, it is not enough to consider these, because the current will have

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different losses in various devices, so we must ensure that sufficient current to drive the MOSFET.

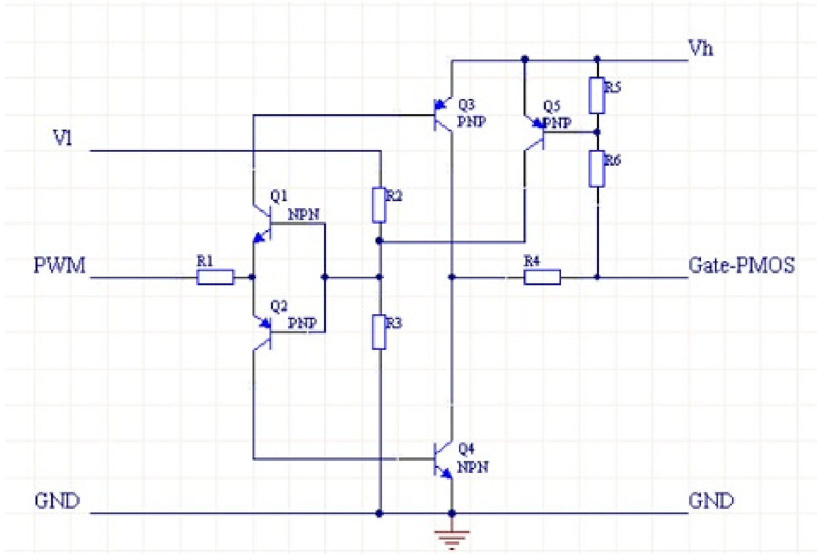

Figure 1. MOS schematic diagram

In this paper, we will discuss the calculation of the MOS gate drive resistor. The range of the MOSFET drive resistance is between 5~100ohms, so how to further optimize the selection of the resistance value in this range?

Equivalent Drive Circuit

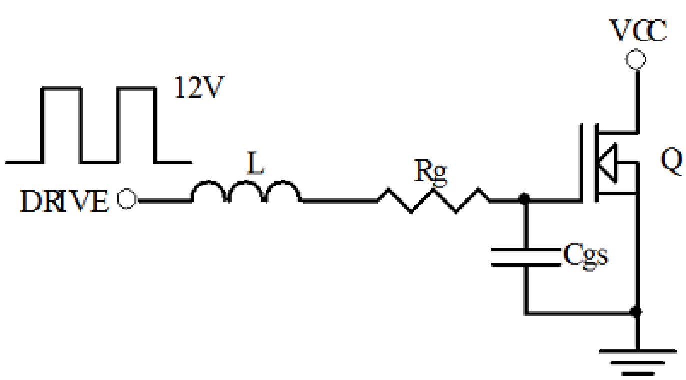

Figure 2. Equivalent drive circuit

L is the PCB line inductor, according to the professional experience its straight line value is 1nH/ mm, considering other line factors, take L=Length +10 (nH), where Length unit is mm.

Rg is the gate drive resistance, and the driving signal is a square wave with a peak value of 12 V.

Cgs is the gate and source capacitance of MOSFET, with different tubes and driving voltage its value will be different, here is 1nF.

$$VL+VRg+VCgs=12V$$

Taking drive circuit:

$$Id := C\left(\frac{\partial}{\partial t}\mathrm{VCgs}(t)\right)$$

Getting differential equation of driving voltage of Cgs:

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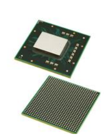

MPC8560PX667LB
Mfr.: Freescale / NXP

$$L\,C\left(\frac{\partial^2}{\partial t^2}\mathrm{VCgs}(t)\right)+C\left(\frac{\partial}{\partial t}\mathrm{VCgs}(t)\right)R+\mathrm{VCgs}(t)-Vdr=0$$

$$Vdr$$

Obtaining Transformation function by method of Laplace transform:

$$G := \frac{Vdr}{L\,C\,S\left(S^2+\frac{1}{L\,C}+\frac{Rg\,S}{L}\right)}$$

This is a third-order system, which is an overdamped vibration when its poles are three different real roots, there are two same solid roots is critical damped vibrations, and there are imaginary roots is underdemped vibrations, which will generate waves of oscillation up and down at the gate of MOFET. This is something we do not want to see, so the choice of gate resistance Rg should make it work in the critical damping and over damping states, but the parameter error is actually working in the overdamped state.

Based on the above, therefore, the minimum range of Rg values can be obtained according to the length of the line.

$$2\,\frac{\sqrt{L\,C}}{C} < Rg$$

Making the length of running line of 20mm and 70mm respectively: L20= 30nH , L70= 80nH, then Rg20=8.94Ω, Rg70=17.89Ω, Here are the voltage and current waveforms

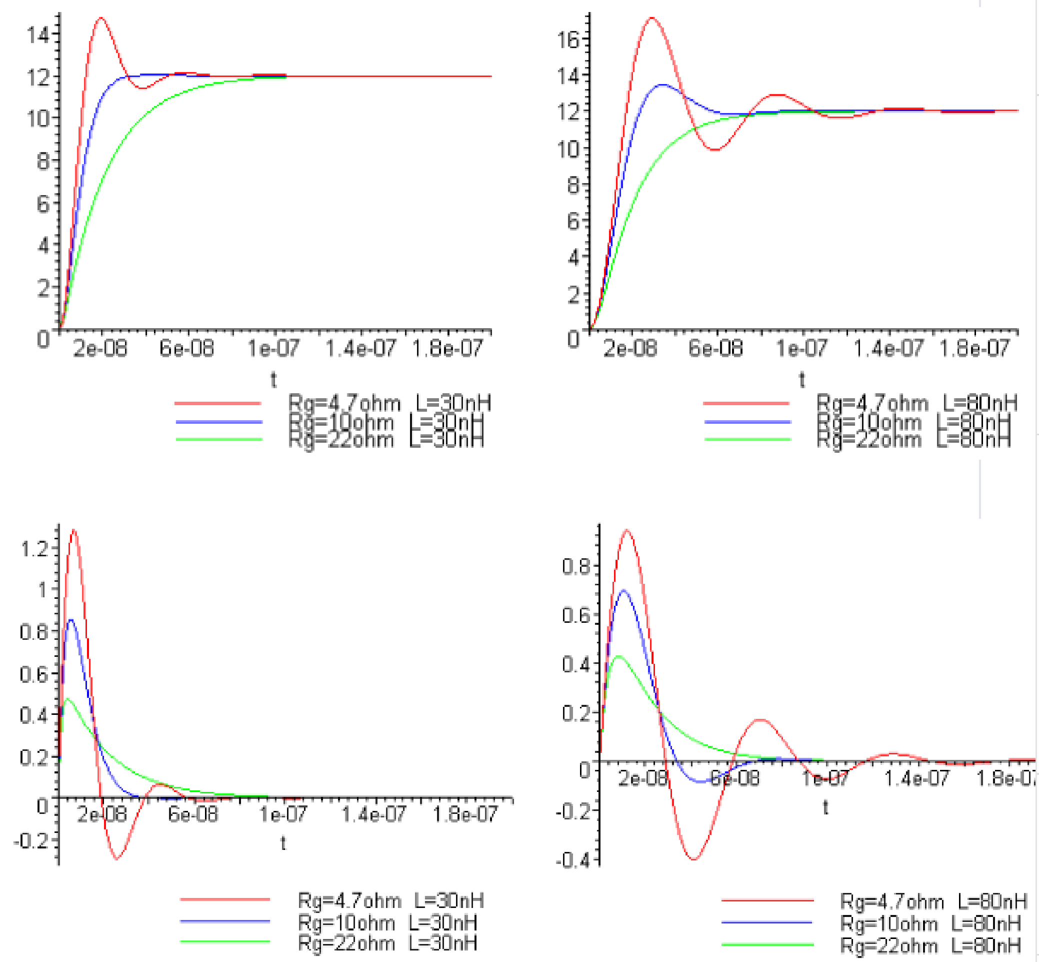

Figure 3. Driving current ripple curve

According to the diagram when the Rg is small, the driving voltage surge will be higher, more and more oscillation will exist when the L becomes large, and the performance of

MOSFET and other devices will be affected obviously. However, when the resistance value is too large, the driving waveform will rise slowly, while it will have a negative effect when the MOSFET has a large current passing through.

In addition, we should note that when L is small, the peak value of driving current is larger, and the output capacity of general IC is limited. When the actual driving current reaches the maximum value of IC output, the output of IC is equivalent to a constant current source. When Cgs is charged linearly, the rising of driving voltage waveform will slow down. The current curve may be shown on the follow (the inductance does not work because the current is constant), this may have an impact on the reliability of the IC, and a small step or burr may occur in the rise of the voltage waveform.

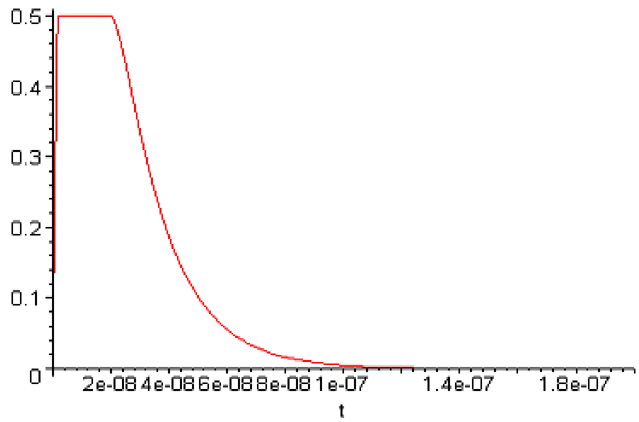

Figure 4. Current curve

The PWM OUT output of the general IC is shown in the left figure. The internal integration includes the current-limiting resistor Rsource and Rsink, usually Rsource > Rsink, but the actual values are related to the peak driving output ability of the IC. It can be approximately considered that R=Vcc/Ipeak. The drive output capacity of IC is about 0.5A, and meanwhile Rsource is about 20Ω.

From the previous voltage and current curves, we can see that the IC driver can drive MOSFET, but the drive line is usually not a straight line, the inductance may be greater, and in order to prevent external interference, it is necessary to use the Rg drive resistor to suppress. This resistance should be as close as possible to the gate of the MOSFET when considering the effect of the line distribution capacitance.

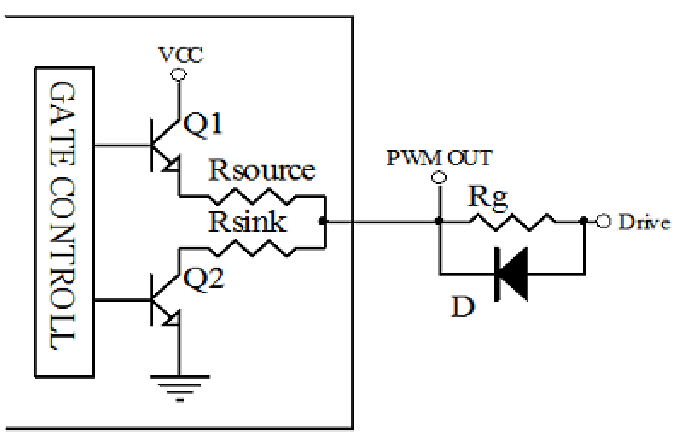

Figure 6. PWM OUT

The effect of Rg and L on rising time: (Cgs=1nF, VCgs=0.9*Vdrive)

TR(nS)	19	49	230	20	45	229
Rg(ohm)	10	22	100	10	22	100

L(nH)	30	30	30	80	80	80

It can be seen that L has little effect on TR, but Rg has great influence on TR. TR can be estimated approximately by 2*Rg*Cgs. Usually, the rise time is less than 20 percent of the conduction time, and the loss of the MOSFET switch when it is switched on will not cause a heat problem. So when the minimum conduction time of MOSFET is determined, the maximum value of Rg is determined $Rg < \frac{1}{40}\frac{Ton\_min}{Cgs}$. Generally, the smaller the Rg is, the better, but if considering the EMI, its value should be taken as large as possible.

The selection of resistor in MOSFET on-state is discussed above. In order to ensure the fast discharge of gate charge in MOSFET off-state, the resistance should be as small as possible, which is the reason of Rsink<Rsource. To ensure rapid discharge, a diode can be connected in parallel on the Rg. When the discharge resistance is too small, it will also cause resonance due to the inductance of the line (so in some applications there will be a small resistance on the diode.). But the reverse current of the diode is not conductive, at the same time, the Rg is involved in the reverse resonant circuit. Therefore, the peak of reverse resonance can be suppressed. This Diodes usually use a high frequency and small signal tube **1N4148**.

In practice, we should also consider the influence of the gate and drain of MOSFET and a capacitor Cgd. When MOSFET is on, Rg has to charge Cgd, which will change the voltage rise slope. When off, VCC will charge Cgs through Cgd. In this case, the charge on Cgs must be removed quickly, otherwise, it will lead to abnormal conduction of MOSFET.

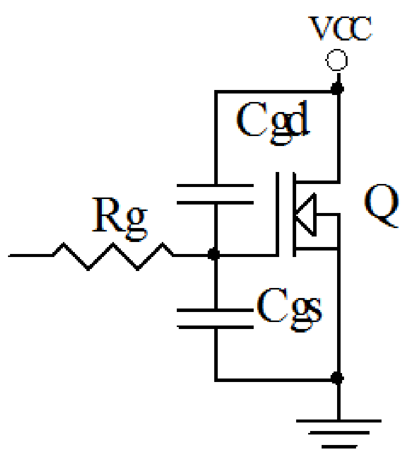

Figure 7. MOSFET schematic diagram

FAQ

1. Why do MOSFETs need resistor?

MOSFET gates are exceptionally high impedance. Just like a GPIO pin set to be an input, a pull-down or pull-up resistor helps keep the transistor on or off during power-on. ... When used with a switch or cable that could be disconnected, it is obvious to use a pull-down or pull-up resistor.

2. Do MOSFETs need pull down resistors?

You either need a resistor to pull it down to ground or you need the input signal to drive it low. ... You only have to drain the inherent capacitance on the MOSFET gate when you're pulling it low so even at a high resistance to ground the RC time constant is usually relatively short.

3. Does Mosfet have resistance?

The MOSFET behaves like a resistor when switched ON (i.e. when Vgs is large enough; check the data sheet). Look in the data sheet for the value of this resistor. It's called Rds(on). It may be a very small resistance, much less than an Ohm.

4. What is the purpose of gate resistor?

A gate resistor is used is to slow down the turn-on and turn-off of the MOSFET. (This is more relevant to power circuits that switch a fair amount of current.)

5. What is Mosfet used for?

The MOSFET (Metal Oxide Semiconductor Field Effect Transistor) transistor is a semiconductor device which is widely used for switching and amplifying electronic signals in the electronic devices. The MOSFET is a three terminal device such as source, gate, and drain.

6. What is Mosfet and how it works?

In general, the MOSFET works as a switch, the MOSFET controls the voltage and current flow between the source and drain. The working of the MOSFET depends on the MOS capacitor, which is the semiconductor surface below the oxide layers between the source and drain terminal.

7. How Mosfet can be used as a resistor?

When you slowly increase the gate voltage the MOSFET slowly starts conducting by entering the linear region where it starts developing voltage across it which we call as VDS . In this region, the MOSFET acts as a resistance of finite value.

8. Can Mosfet switch AC?

Yes, but you need to connect two back to back to deal with the body diode. Connect the source terminals and gate terminals and connect a floating voltage supply between sources and gates. This circuit is typically called a solid state relay.

9. How much current can a Mosfet handle?

Modern MOSFETs can have on resistances of less than 10 milliohms. A little math shows that this device can handle 10 amps with one watt converted into waste heat (power = current2 x resistance). Since many MOSFETs come in TO-220 packages, no heatsink is needed in this instance.

10. How many types of Mosfet are there?

four types. There are two classes of MOSFETs. There is depletion mode and there is enhancement mode. Each class is available as n- or a p-channel, giving a total of four types of MOSFETs. Depletion mode comes in an N or a P and an enhancement mode comes in an N or a P.

About the Author

Kynix

Kynix

Kynix was founded in 2008, specializing in the electronic components distribution business. We adhere to honesty and ethics as our business philosophy and have gradually established an excellent reputation and credibility in our international business. With the accurate quotation, excellent credit, reasonable price, reliable quality, fast delivery, and authentic service, we have won the praise of the majority of customers.

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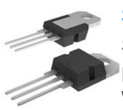
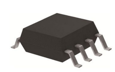
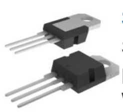
	**STP5NK100Z** STMicroelectronics MOSFET 3.5 A Through Hole 1 Channel - 55 C TO-220-3 125 W N-Channel 1000 V	Call	Inquiry
	**BSZ040N04LSG** VISHAY	1+: $6.11072 10+: $5.76483 100+: $5.43852 500+: $5.13068 1000+: $4.84026	Buy
	**STP100N10F7** STMicroelectronics MOSFET 80 A Through Hole 1 Channel - 55 C TO-220-3 150 W N-Channel 100 V	1+: $15.28519 10+: $14.41999 100+: $13.60376 500+: $12.83374 1000+: $12.10730	Buy
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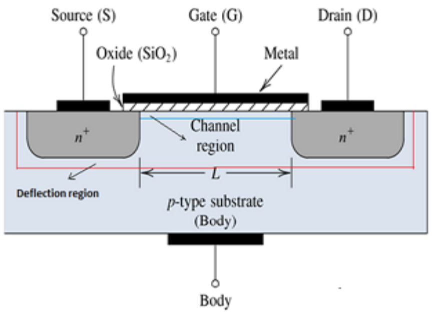

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