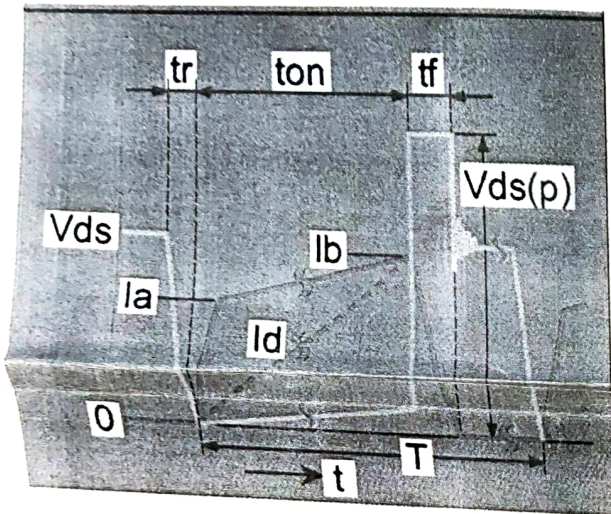


# The advantages analysis of Super Junction MOSFET on the high switching frequency LED Driver

In the power electronics field, the big trend in power supply is shrinking the size and weight of magnetic components via increasing the working frequency. The traditional VD-MOSFET (Planar MOSFET) would face problem like high temperature-rising in high frequency application environment. However SJ-MOSFET(Super Junction MOSFET) has a lower  $C_j$ (Junction Capacitance), which is more suitable for high switching frequency. Based on Power consumption analysis and practical case, this paper will analyze the application advantages of SJ-MOSFET.

## 1. MOSFET switching power loss analysis

When Power MOSFET works in the high frequency, the charging and discharging of high input capacitance will lead to large switching loss. The on&off waveform as below:



During  $T_r$ ,  $P_t$  can be ignored comparing with  $P_{ton}$ ,  $P_{tf}$ ;

During  $T_{on}$ :

$$\text{(Full line) CCM: } P_{ton} = \frac{1}{3} (I_a^2 + I_a \cdot I_b + I_b^2) R_{on} \alpha \cdot t_{on} / T \quad (\text{formula 1})$$

$$\text{(Imaginary line) DCM: } P_{ton} = \frac{1}{3} \cdot I_b^2 \cdot R_{on} \cdot \alpha \cdot t_{on} / T \quad (\text{formula 2})$$

$$\text{During } T_{off}: P_{toff} = \frac{1}{2} \cdot V_{ds(p)} \cdot I_b \cdot \frac{t_{ff}}{T} \quad (\text{formula 3})$$

$\alpha$  is the  $R_{dson}$  temperature coefficient:  $\alpha = T(x^\circ C) / (T(25^\circ C))$ ;

$$T_r = R_{\theta} \cdot [C_{gs} + C_{gd}(V_{ds})] \ln \left( \frac{V_{GP}}{V_{TH}} \right) \quad (\text{formula 4})$$

Referring to formula 4,  $T_r$  is positive proportion to  $R_G, C_{GS}, C_{GD}$ ;

With same  $R_{dson}$ , the  $C_{GS}, C_{GD}$  of SJ-MOSFET will be smaller 2-3 times, and the corresponding turn-off loss is lower 2-3 times than VD-MOSFET.

From formula 3, the higher switching frequency  $f$  is, the higher  $P_{toff}$  is, if decreasing  $I_b$  and  $t_{ff}$ , the loss increasing aroused by the frequency increasing can be offset.

Referring to above analysis, SJ-MOSFET is more suitable for higher switching frequency, such as increasing the switching frequency from 65KHZ to 100KHZ-200KHZ.

## 2. The advantages analysis of high frequency application

a. High frequency Power supply Primary side, MOSFET has a lower current stress

The  $I_{peak}$  of classic power supply IC controller UC3842 CCM module is calculated as below:

$$I_{PK_{MOSFET}} = \frac{P_{IN}}{V_{BULK(min)} \times \frac{N_{PS} \times V_{OUT}}{V_{BULK(min)} + (N_{PS} \times V_{OUT})}} + \left( \frac{V_{BULK(min)}}{2 \times L_m} \times \frac{N_{PS} \times V_{OUT}}{V_{BULK(min)} + (N_{PS} \times V_{OUT})} \right) \cdot \frac{1}{f_{sw}} \quad (\text{formula 5})$$

CYG WAYON CIRCUIT PROTECTION CO., LTD.  
No.1001, Shiwan 7th Road, Pudong District, Shanghai, P.R.China.201207  
Tel: 86-21-68960674

Email: mosfet@way-on.com  
MOSFET.WAY-ON.com

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throughout the country. In addition, a major amount of carbon footprint can be reduced. Especially in states where there is abundant sunlight throughout the year, domestic buildings and offices can greatly benefit from solar energy.

However, solar installations require end-users to follow a strict checklist to ensure proper return on investment (ROI). There are many market challenges as well, which need to be addressed. To understand solar rooftops better, EFY spoke with Maxson Lewis, managing director, Magenta Power Pvt Ltd. Excerpts are as follows:

**Q. What are some important points to consider for solar rooftops?**

**A.** Two important parameters that can help you decide whether you should invest in a solar rooftop are maintenance and ROI.

In terms of maintenance, there are two aspects: shading and dust. If a part of the solar panel comes under shade, the whole panel becomes inefficient.

Unfortunately, in many cases, shade of one panel falls on the other. This is because there are no regulations in place for such installations. Internationally, there are rules for installation and governing guidelines for design, configuration, safety and deployment of solar rooftops. Some Indian state discoms follow certain guidelines, but nowhere near as in-depth as the ones in, say, the US and Europe. This is a major reason why many people do not get proper payback. Installation must follow a proper string design.

As part of maintenance, rooftop panels need to be installed in such a way that these can be cleaned at least once a month. There are fabrication solutions to ensure this. For instance, Magenta Power provides a walk-way that not only guarantees access but also ensures safety. Deployment must be at an accessible position.

In terms of ROI, you should look at it from a 25-year perspective. Solar is a long-term solution. Moreover,

installation should be done with all sorts of safety and security parameters in place. You should analyse the various technical elements and costs associated for understanding their tentative benefits.

**Q. Are the prices affordable enough to invest in this technology?**

**A.** The prices are coming down. Three years ago, the cost was close to ₹ 90,000 - ₹ 100,000 per kW. Last year it was about ₹ 60,000 per kW. This year, it is down to about ₹ 50,000 per kW.

This is the best time to invest in solar. China's panel market has kind of crashed. All panels are now open in the market, forcing others to deliver it at a lower price point. However, it has reached a point where optimisation in input cost has already happened. I do not see it going any further down. Anything lower will have a trade-off with quality. Hence, I believe that the next two years will be the most profit-

**Q. Are there any solutions for those who live in rented properties?**

**A.** It is understandable that many people living in rented accommodations may not want to invest a high amount. However, there are solutions for them as well. We have devised a portable solar solution that can be installed in a day or two—and be dismantled in one day. We have done this in a lot of places, including a school in Mumbai that had plans of renovation in another two years. The whole system was of 20kW capacity.

The cost of the portable system is about the same as that of the traditional one. However, the main advantage is portability. In the traditional system, wiring is the reason it cannot be moved often. Moreover, it takes up to two weeks to install. However, you should go for a portable system only if you plan to stay in the same place for at least two to three years.

**Q. Are there any legal regulations associated?**

**A.** There are some regulations across various municipalities. For instance, in Mumbai, if you live in a rented flat where only you want

solar—and no one else—there is a law called Bye Law 171. This lets you apply for solar and the rest of the housing is obliged to give you space for the same.

However, there is no law surrounding the structure that is required for installation of solar on a building because it is a temporary structure. Hence, there is no formal procedure of applying and getting approvals for this structure.

**Q. What are the market challenges that need to be addressed?**

**A.** While there is a lot of talk about solar in the media, various conferences and events, at the end-user level, practical awareness is limited. People know that solar technology exists and, in some way, beneficial for power generation. But the business case for solar rooftop—how benefits will come in—is not clear to the consumers.

The aim of industry players and media alike should be to talk more about the various benefits. For instance, till today, people have the notion that the payback period of rooftop solar is over five years. It has to be explained that ROI period has come down to four years, or earlier.

Moreover, people do not have clarity on the concept of net-metering. They still go by the investment required in batteries. We have to make them understand that net-metering does not require a battery and, thus, the cost of installation is lower.

Policies also play a major role in creating awareness. Today, different states have different solar policies. And the way every policy is executed at ground level is different. This needs to be improved.

Then, getting the help of discoms to set up solar and net-metering is difficult, especially in Maharashtra. While many discoms in Mumbai are helpful, rest of the state faces many challenges. Discoms believe their revenue will go down if people start using solar instead of relying on the grid. They are taking solar as competition. They need to be explained that micro-generation helps stabilise the grid. **EFY**