What Affects the Current Capacity of a Switch?

The analog switch is widely used in applications such as sweeper robots, network switches, communication base stations, etc. The analog switch is mainly used for signal switching, including selecting system input signals, controlling signal switching of power amplifier, and switching communication interface.

As the analog switch is not an ideal switch, the resistance and capacitance introduced by the switch can reduce the amplitude of the input signal and cause the waveform distortion problem. Therefore, the selection of switch parameters needs to be based on the accuracy requirement of the system.

In communication applications, switches are usually used to switch power control signals for transmitting and receiving channels, or for power amplifier protection in the TDD mode. At this time, due to the parasitic capacitance, the switching process can cause current surges, so the current capacity of the switch needs to be additionally considered.

This article mainly discusses how to evaluate the current capacity of the switch. The current capacity of the switch is mainly affected by the power consumption of the chip, the heat dissipation capacity of the package, and the current capacity of the internal design in the chip. These factors are discussed in detail below.

1. Power Consumption and Heat Dissipation Capability

When the switch is turned on, it is equivalent to a resistance. The value of the on-resistance (Ron) of the switch which is related to the condition of power supply voltage, input/output voltage, other conditions that can be found in the datasheet of the switch.

The resistance is connected between the input and output. When current flows through it, the resistance generates power loss, thereby generating heat. The current capacity limited by heat can be calculated based on the thermal resistance of the switch, the maximum supported junction temperature, and the required ambient temperature.

The TPW4157 SPDT switch from 3PEAK with low on-resistance impedance has a typical Ron value of 0.95 ohm when the supply voltage is 4.5 V. The thermal resistance (θ_{JA}) of the SC70 package is 400 °C/W.

Assuming that the operation ambient temperature of the product is up to 65 °C, and the maximum junction temperature supported by the chip is 150°C. The current passing through the switch is Ion. According to the heat dissipation capacity of the switch，the current capacity can be calculated using the heat calculation formula：

$$Ion^2 * Ron \leq (150 - 65)/400 \qquad (1)$$

Thus, the maximum Ion can be calculated as below:

$Ion(max) = 0.47A$

2. Internal Design Limitations

The current capacity of the switch also depends on the internal design.

The main constraints on the current capacity are metal traces and the vias which connect various metal layers. In the design of analog switches, the via has a much greater current capacity than the metal trace. Therefore, the current capacity affected by design mainly depends on the width of the metal trace.

The minimum width of metal trace in TPW4157 is 52 μm. According to the relevant design documents, the relationship of metal trace width, continuous current flow capacity, and peak current flow capacity can be found as shown in the table below:

Table 1 Average DC Current

Layer	Material	Idc(mA) for minimum width
Metal Layer	Al	1.68

Table 2 Specification of Peak current

Item	Layer	Ipeak(mA/um)
Metal line	Metal Layer	$30*W^{-0.32}$

Note: W refers to the width of the metal trace and the unit is μm. The temperature for these parameters is the junction temperature of 110℃.

By calculating, the continuous current guaranteed by TPW4157 design is:

$$1.68\, mA/\mu m \times 52\, um = 87.4\, mA \quad (2)$$

And the peak current is：

$$[30 \times 52^{-0.32}] mA/\ \mu m \times 52\ \mu m = 440.6\, mA \quad (3)$$

By calculating the continuous current capacity and peak current capacity, it is possible to evaluate whether the selected switch meets the requirements in the switching scenario.

If the current passing through the switch changes periodically and with a duty cycle of D, peak current Ip, and valley current IL, we can calculate the average current using the following formula:

$$I_{RMS} = I_p \times D + I_L \times (1 - D) \quad （4）$$

In addition to ensuring that the peak current is within the withstand capacity of the switch, it is also necessary to ensure that the average current is less than the continuous flow current capacity of the switch.

3. Summary

In summary, evaluating the current capacity of a switch usually requires analysis from both design and application perspectives. If the on-resistance of the selected switch is small, the current capacity is mainly limited by the width of the metal traces inside the switch.

The analog switch products of 3PEAK have advantages such as high bandwidth, low on-resistance, etc. The analog switch products can meet the requirements of consumer, industrial, and communication applications that need switching of audio signals, IO signals, and interface signals.