Selection of Discrete Components for PoE Systems

1. Introduction

Power over Ethernet (PoE) is a technology that allows both power and data to be transmitted simultaneously over Ethernet cables. This technology is especially useful when surveillance cameras are installed in difficult-to-reach locations, as it eliminates the need for an additional power line. With just one network cable, both video and power can be transmitted, typically supporting distances up to 100 meters. The PoE system consists of two main elements: Power Sourcing Equipment (PSE) and Powered Devices (PD). To ensure the stable and reliable operation of the PoE system, the selection of discrete components such as MOSFETs, TVS, ESD protection, and Diodes is important.

This Application Note uses TI's PoE solution as an example to discuss the roles of the above components in PSE and PD to help engineers design PoE systems with high reliability and protection capabilities.

2. PoE System Architecture Overview

The role of a network switch is like Power Sourcing Equipment (PSE), which provides 15W/30W/60W~90W and power management functions according to IEEE 802.3af/at/bt standards. The IP camera or Wi-Fi AP acts like a Powered Device (PD), communicating with the PSE about power requirements and receiving power. As shown in figure 1.

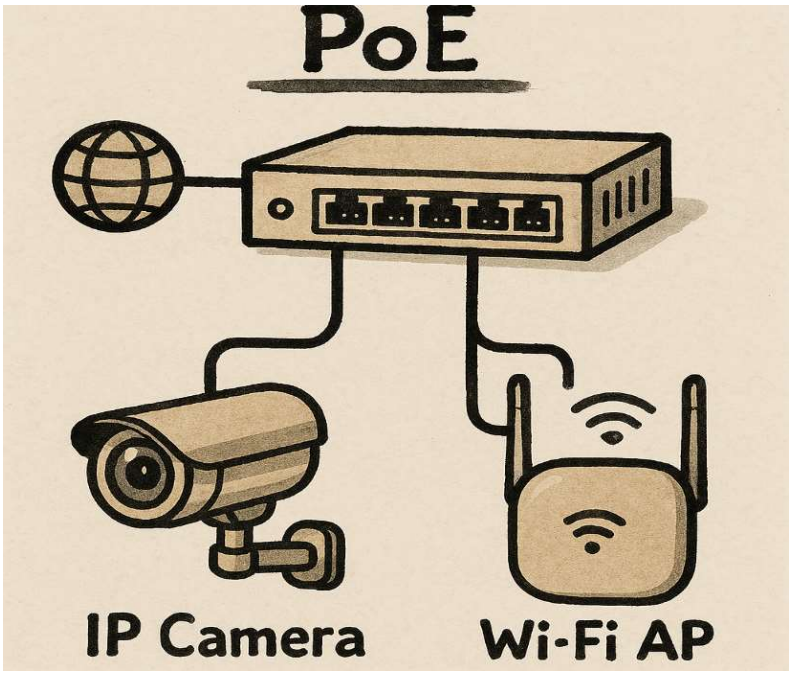

Figure 1. PoE System Architecture

The PoE voltage range is typically 44V to 57V, with a maximum output power of up to 90W (802.3bt). Due to environmental challenges such as hot swapping, voltage spikes, and electrostatic discharge (ESD) in the network cables connecting PSE and PD, selecting the appropriate protect components and discrete components can effectively protect the system and enhance performance.

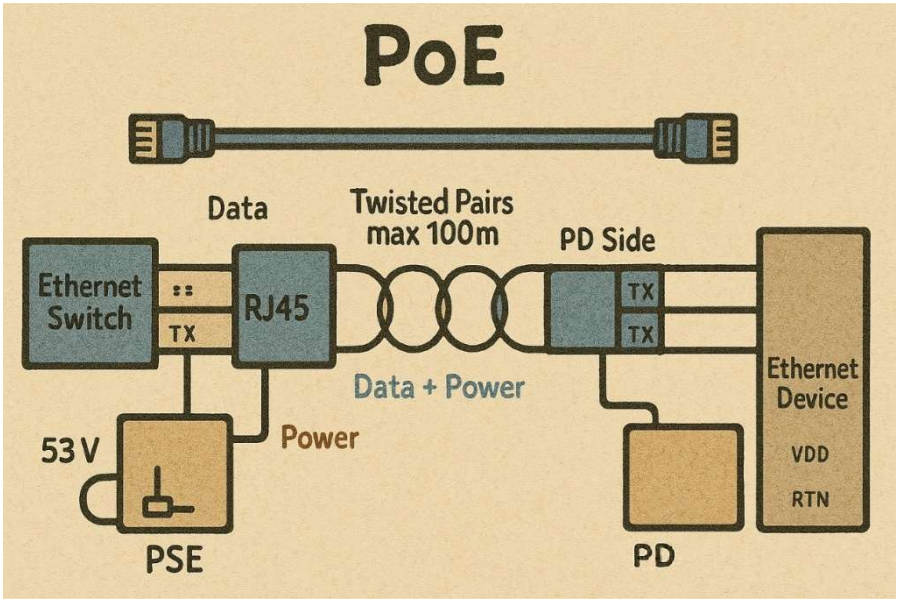

Figure 2. Ethernet cables are easily affected by the harsh environments

3. Discrete components selection for PSE

Taking TI's solution as an example, the MOSFET for each channel is external. Compared to solutions with built-in MOSFETs, the disadvantage of external MOSFETs is that they occupy more PCB space. However, the advantage is that heat dissipation can be spread across the external MOSFET. Heat will not be concentrated in a single chip.

When a PD is connected to PSE via ethernet cable, the PSE will send a small voltage first to detect whether the device is a valid PD device. This process is called detection. If the device is not a legitimate PD, no power will be provided to avoid damaging the equipment.

Once the device is confirmed to be a legitimate PD, the PSE will perform a handshake with the PD to determine how much power the PD requires and how much power the PSE can supply. This process is called classification. During this process, the MOSFET operates in the linear region for a very short time.

After classification process, PSE will fully turn on the MOSFET, and the MOSFET will enter the saturation region, functioning like a switch. Since the maximum PoE voltage is 57V, the recommended N-MOSFET withstand voltage is greater than 80V, and 100V N-MOSFET is generally selected. During operation, the PSE will continuously detect the MOSFET voltage, current and timing. It is recommended that the V_{DSS} withstand voltage of N-MOSFET is 100V and $R_{DS(ON)}$ is 50mΩ ~ 150mΩ to reduce losses. The package is PowerPAK or DFN to help dissipate heat. Ciss is less than 2000pF or Qg is less than 50nC.

The RJ45 port of PSE is easily affected by external static electricity and noise interference, which may cause data errors or even device damage. Therefore, it is necessary to place ESD on the port. The ESD specification depends on the ESD protection specification of the switch (ex. +/-2KV, +/-6KV, +/-8KV...). For differential electrostatic test, it is recommended to place ESD (line capacitors <1pF to avoid affecting signal) between 54V and MOSFET Drain and between MOSFET Drain and ground (**) and close to the RJ45. As shown in figure 3.

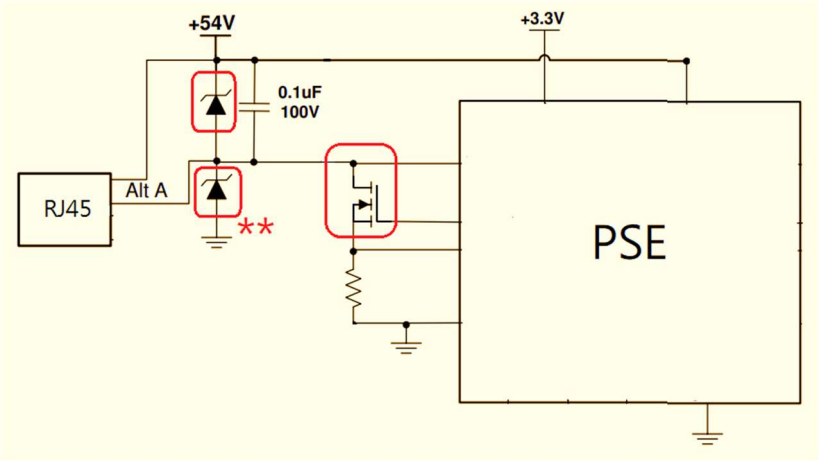

Figure 3. Discrete components in PSE

4. Discrete components selection for PD

Since the Alt-A of RJ45 does not specify whether to connect to positive or negative power, a diode bridge needs to be connected to the front of the PD device, and then connected to the DC\DC. Due to safety considerations, DC\DC recommends using isolated flyback or forward to regulate 57V voltage to a lower voltage for system power.

For an output 5V/ 25W flyback topology, it is recommended the specifications of discrete devices: 100V/2A Schottky Diode bridge, 58V Unipolar TVS, 150V/4A N-MOSFET, 30V/19A N-MOSFET, 200V/1A Ultrafast Diode. As shown in figure 4.

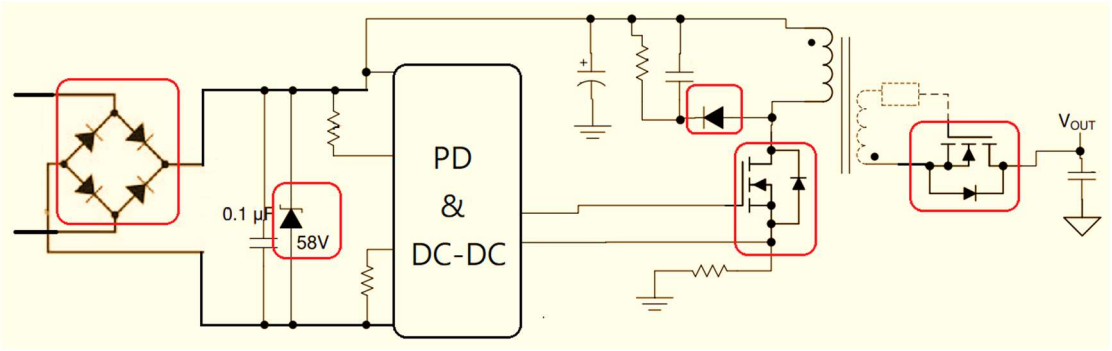

Figure 4. Discrete components in PD

5. Summary

PoE systems are increasingly used in smart homes, industrial automation, and network devices. The selection of discrete components plays a key role in the stability and safety of the overall system. Through reasonable selection and layout design, the product's anti-interference ability and long-term operating performance can be effectively improved.

6. Reference

1. TPS23881B datasheet,TI, 2024
2. TPS23731 datasheet,TI, 2020
3. Overview of 802.3bt - Power over Ethernet standard, ethernet alliance, 2018