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In-depth analysis of electromagnetic compatibility solutions for immunoassay analyzer electronic circuits

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1. International/Domestic Industry Standards Interpretation

1.1 International Industry Standards

Internationally, immunoassay analyzers must comply with strict industry standards. For example, the EU's 2004/108/EC Directive (the EMC Directive) sets clear requirements for the electromagnetic compatibility performance of electrical and electronic products, stipulating that from January 1, 1996, all electrical and electronic products must pass EMC certification and be affixed with the CE mark before they can be sold on the European Community market. The U.S. Federal Code CFR47/FCCCrules also makes clear provisions for electromagnetic compatibility certification. In related fields such as laboratory medicine and medical equipment, the international standard classification has detailed specifications for chemical immunoassay analyzers, covering all aspects from product design to performance testing. These standards are intended to ensure the quality, safety and compatibility of immunoassay analyzers worldwide and promote international trade and technical exchanges.

1.2 Domestic Industry Standards

In the Chinese standard classification, chemical immunoassay detectors involve multiple fields such as medical laboratory equipment, basic discipline integration, and medicine. Industry standards - medicine have issued standards such as YY/T 1174-2010 Semi-automatic Chemiluminescence Immunoassay Analyzer, which stipulates the requirements, test methods, signs, labels and instructions, packaging, transportation and storage of semi-automatic chemiluminescence immunoassay analyzers. There are also national standards such as GB/T 40265-2021 General Rules for Enzyme Immunoassay Antibody Testing and GB/T 44830-2024 General Rules for Enzyme-Linked Immunoassay Kit Testing, which regulate the use and testing procedures of immunoassay analyzers from different aspects, ensure the compliance and reliability of related products in the domestic market, and promote the healthy development of domestic immunoassay technology.

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2. EMC test related requirements

2.1 EMC test standards

EMC testing standards are numerous and important. For example, GB4343-1995 "Measurement methods and allowable values of radio interference characteristics of household and similar electric and heating appliances, electric tools and similar electrical appliances" stipulates the measurement methods and allowable values of radio interference characteristics of relevant electrical appliances. It was issued on August 25, 1995 and implemented on December 1, 1996. GB4343.2-1999 "Electromagnetic compatibility - Requirements for household appliances, electric tools and similar appliances - Part 2 - Immunity" focuses on the immunity of appliances. It was issued on March 23, 1999 and implemented on April 1, 2000. There is also GB "Limits of harmonic currents emitted by low-voltage electrical and electronic equipment (equipment with a current of £16A per phase)", which limits the harmonic currents emitted by low-voltage electrical and electronic equipment. It was issued on February 9, 2003 and implemented on May 1, 2003, replacing the old standards. These standards provide clear quantitative indicators and operating specifications for EMC testing.

2.2 EMC test content

EMC testing covers a wide range of content, including conducted emissions, radiated emissions, conducted immunity, radiated immunity, ESD immunity, temporary immunity, surge immunity, etc. Conducted and radiated emissions are related to the ability of the device to transmit radio frequency energy, while conducted and radiated immunity are related to the device's ability to resist the impact of radio frequency energy. ESD immunity tests the device's resistance to electrostatic discharge, ensuring that the device will not be damaged by static electricity during daily use. Temporary immunity and surge immunity test the device's ability to withstand transients or surges on the line. After all, the main power supply is often affected by surges and transient pulses, and the device needs to be able to operate stably. Different test contents ensure the electromagnetic compatibility of the device from multiple dimensions.

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3. Analysis of pain points in the analyzer EMC industry

3.1 Technical Pain Points

From a technical perspective, immunoassay analyzers face many challenges. International technology blockades may hinder the supply of key components, affecting product production and upgrades. For example, if key components such as high-precision magnetic beads and sensors rely on imports and encounter technology blockades, companies will be in trouble. The mismatch between the speed of technological iteration and R&D investment is also a problem. Rapid technological updates require companies to continuously invest large amounts of money in R&D, but some companies may be unable to keep up with the pace of technological development due to insufficient funds or strategic mistakes, resulting in a decline in product competitiveness and gradual elimination in the market.

3.2 Pain Points at the Market Level

At the market level, the downward pressure on prices brought about by the centralized procurement policy is huge. In order to reduce medical costs, the centralized procurement policy has caused a sharp drop in the price of immunoassay analyzers, which has compressed the profit margins of enterprises and may affect their R&D investment and market expansion capabilities. The localized competition strategy of multinational companies has also brought an impact on domestic companies. Foreign companies such as Roche and Abbott have dominated the domestic high-end market with their technological accumulation and brand advantages. Through localized production and sales, they have further squeezed the market share of domestic companies. Domestic companies need to work hard to improve their own strength to cope with competition.

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4. Circuit design EMC solutions

4.1 EMC Problem Analysis Method

When analyzing EMC problems, a variety of methods can be used. The elimination method is suitable for complex systems. Each part of the product is shut down or removed one by one, leaving only the minimum system working, to determine whether the minimum system meets the EMI standard limit requirements. If the minimum system is not a problem, then gradually restore other parts and compare the test results to locate the EMI source or path. The near-field scanning method uses a spectrum analyzer and a near-field probe to perform a near-field scan of the radiated electromagnetic field of the product as a whole or in part to preliminarily determine the risk area or location. These two methods can be used in combination to improve the accuracy and efficiency of problem analysis.

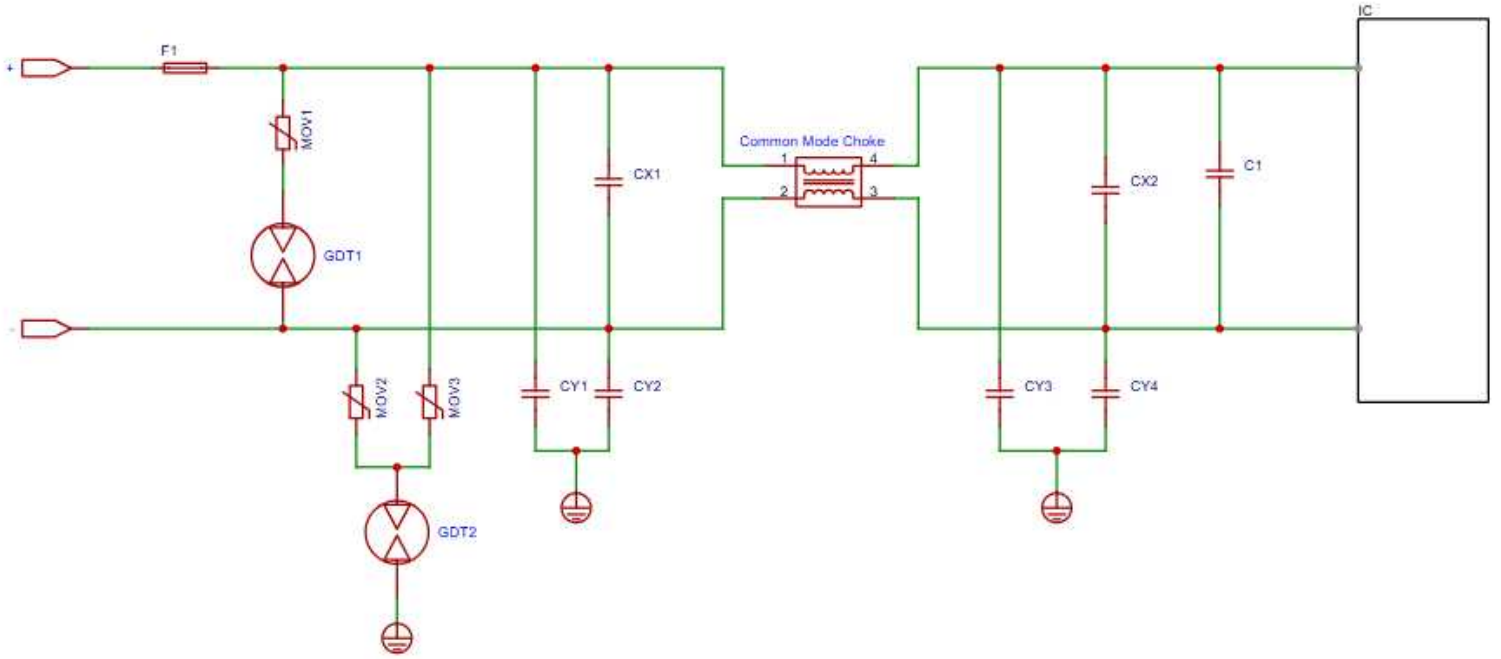
4.2 Specific Solutions

Power supply issues: This could be caused by improper component selection or PCB design in the DC-DC circuit. Component selection (DC-DC chips, inductors, diodes) should be reviewed, and the PCB design optimized to ensure power supply stability and reduce electromagnetic interference.

Clock issues: Traditional solutions can employ methods such as hardware spread spectrum, or consider replacing the solution to reduce clock signal interference. To address ground imbalance, focus on circuit layout and grounding design to ensure balanced ground potential and reduce interference caused by ground currents. These specific solutions can improve the electromagnetic compatibility of immunoassay analyzer circuits.

4.3 AC power interface EMC and reliability design

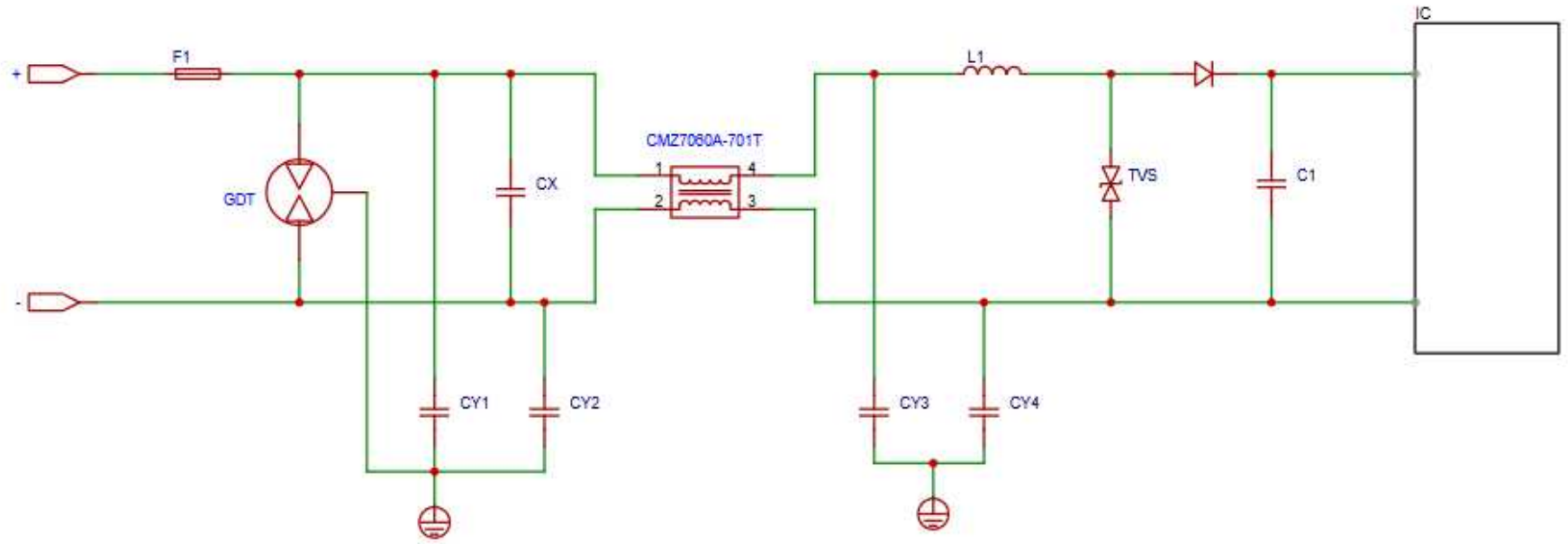
AC power interface: used to connect external 220V AC input



model	Device Type	Use Location	effect	Encapsulation
2R600L	GDT	power interface	Surge and lightning protection (for outdoor products, pay attention to the issue of continuous current)	2RXXXL
14D561K/14D511K	MOV	power interface	Surge and lightning protection	14D
CMZ/CML	EMI common-mode suppressors	power interface	Common-mode rejection	SMD

4.4 DC power interface EMC and reliability design

DC power interface: used to connect an external power adapter (such as 5V/12V DC input). Some devices support power supply via USB.

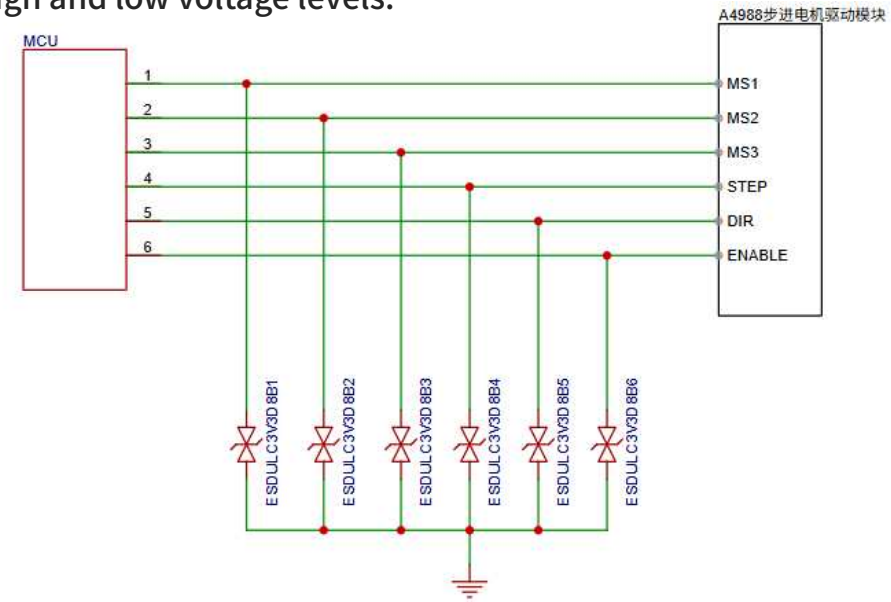


model	Device Type	Use Location	effect	Encapsulation
3R090L	GDT	Power interface	Surge and lightning protection (for outdoor products, pay attention to the issue of continuous current)	3RXXXL
SMBJ6.5CA	TVS Transient Voltage Suppressor Diodes	Power interface	Surge, load dump	SMB/Do-214AA
SMCJ15CA	TVS Transient Voltage Suppressor Diodes	Power interface	Surge, load dump	SMC/Do-214AB
CMZ7060A-701T	EMI common-mode suppressors	Power interface	CE conduction, common mode suppression, smaller current, consider small encapsulation	7060

4.5 Stepper Motor Driver Module Interface EMC and Reliability Design

MCU interface：

The A4988 receives control signals from the MCU through multiple pins and controls the stepper motor simultaneously. STEP receives pulse signals from the MCU to control the number of steps of the stepper motor. DIRECTION controls the direction of the motor through high and low voltage levels. ENABLE is active at a low level, starting the drive and high at a high level stopping it. MS1-MS3 set the subdivision mode (full step, half step, quarter step, etc.) by combining high and low voltage levels.

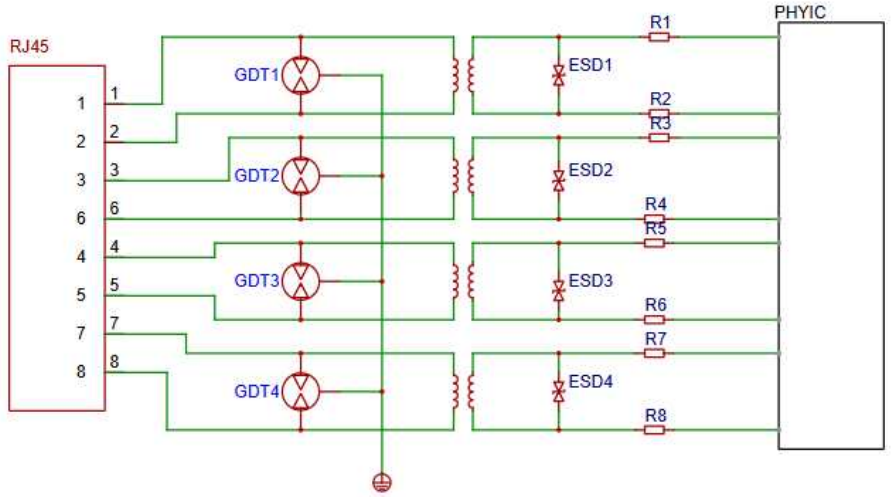


model	Device Type	Use Location	effect	Encapsulation
ESDULC3V3D8B	ESD	MCU interface	Surge, static electricity	SOD882

4.6 Ethernet Interface EMC and Reliability Design

Ethernet interface:

Supports wired network connection; provides stable network connection for the machine, supports remote control and data interaction. Through Ethernet, the machine can upload working data to the cloud in real time, receive remote commands, and realize intelligent remote operation; its transmission rate can reach 1000Mbps or even higher, meeting the machine's demand for high-speed and stable data transmission in automation, intelligence and other fields.

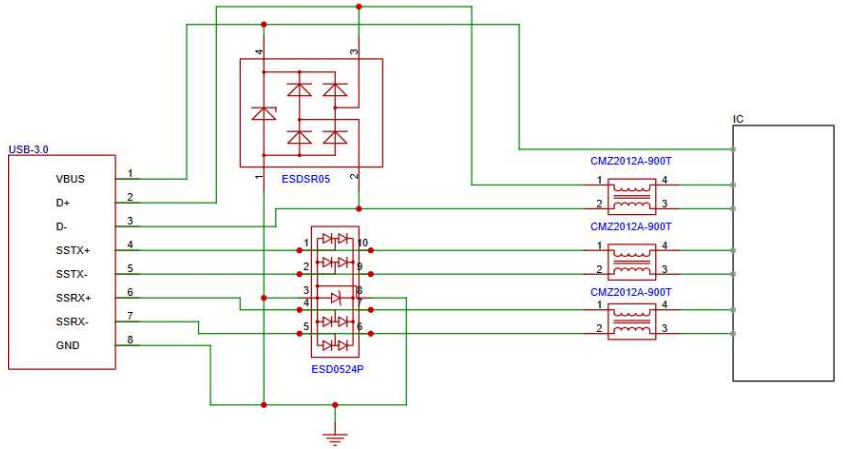


model	Device Type	Use Location	effect	Encapsulation
3R090L	GDT	Ethernet interface	surge	3RXXXL
ESDLC3V3D3B	ESD	Ethernet interface	Surge, static electricity	SOD323

4.7 USB 3.0 interface EMC and hot-swap reliability design

USB 3.0 interface:

The USB interface has high-speed data transmission capabilities and is widely used to connect machines with external storage devices, sensors, etc. Its data transmission rate in high-speed mode can reach 5Gbps, which can quickly transmit large amounts of data, such as machine vision image data; it has a plug-and-play feature, which makes it convenient for users to connect and replace devices at any time, improving the convenience of machine use and playing a key role in various machine application scenarios.

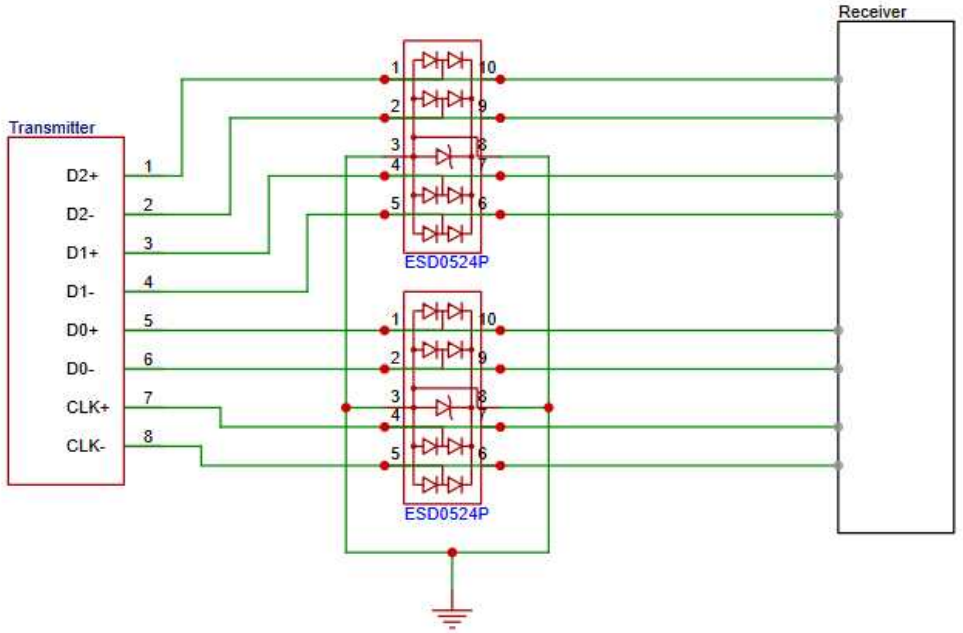


model	Device Type	Use Location	effect	Encapsulation
ESD0524P	ESD	USB interface	Surge, static electricity	DFN2510
ESDSR05	ESD	USB interface	Surge, static electricity	SOT143

4.8 LVDS Interface EMC and Reliability Design

LVDS interface:

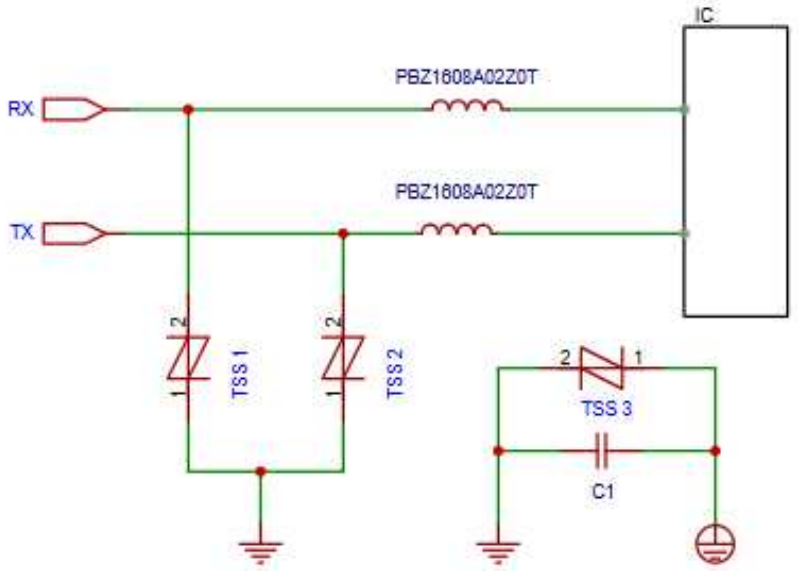
LVDS is a low-voltage differential signaling technology that uses a low swing voltage (about 350mV) to transmit data through a pair of differential lines, supporting transmission rates of up to several thousand Mbps. Its core advantages include low power consumption, low noise, and strong anti-interference capabilities. It is widely used in high-speed backplanes, cables, and PCB communication links.



model	Device Type	Use Location	effect	Encapsulation	Features
ESD0524P	ESD	LVDS interface	Surge, static electricity	DFN2510	Large dosage, high value ratio

4.9.1 RS-232 Interface EMC and Reliability Design

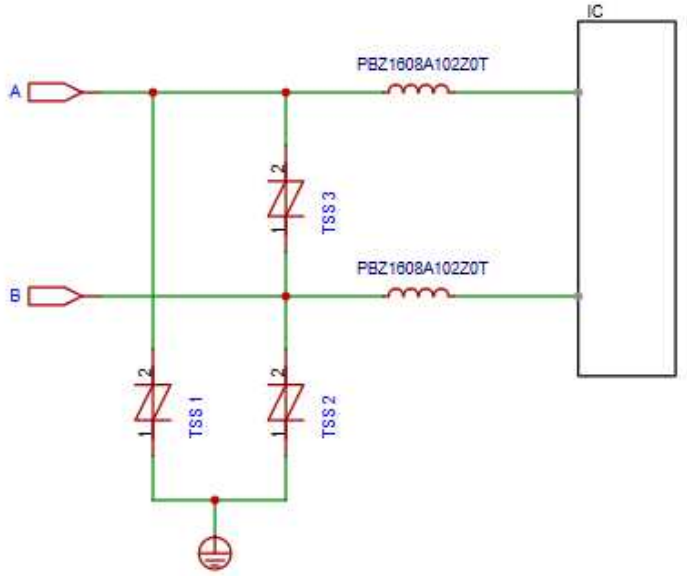
RS232 interface: It is one of the commonly used serial communication interfaces. RS232 is suitable for short-distance device interconnection (such as printers, mice, etc.), but it requires a level conversion chip (such as MAX232) to adapt to different logic levels.



model	Device Type	Use Location	effect	Encapsulation
P0220SCL	TSS	RS232interface	Surge, static electricity	SMB
P3100SCL	TSS	RS232interface	Lightning strike、Surge, static electricity	SMB
PBZ1608A02Z0T	magnetic beads	RS232interface	Eliminate high-frequency interference	1608

4.9.2 RS-485 Interface EMC and Reliability Design

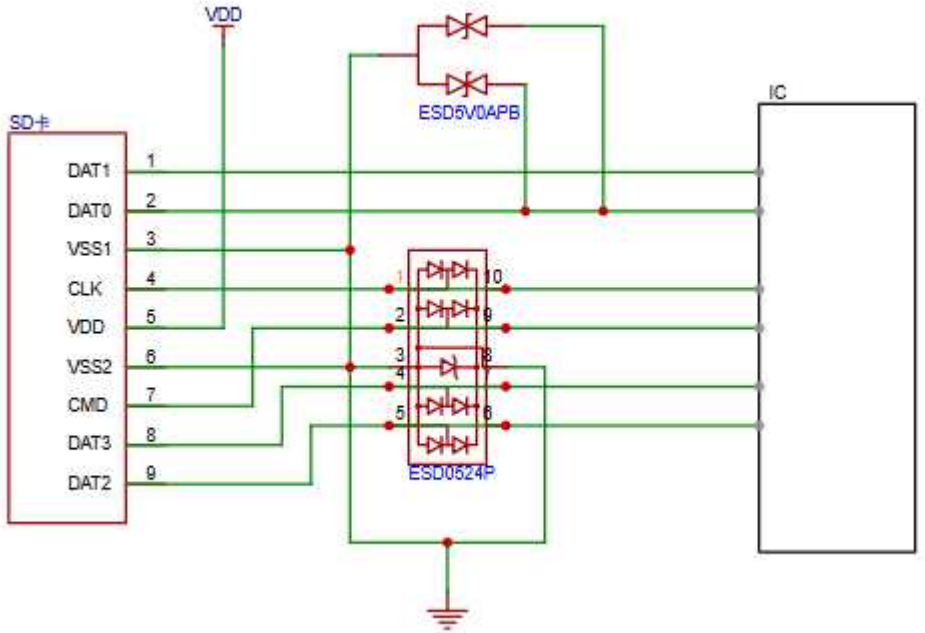
RS485 interface: RS-485 is a serial communication standard that can support multiple devices to communicate through the same serial bus. It is suitable for medium and long distance communication and has good anti-interference ability and data transmission stability.



model	Device Type	Use Location	effect	Encapsulation
P0080SCL	TSS	RS485interface	Surge, static electricity	SMB
PBZ1608A102Z0T	magnetic beads	RS485interface	Eliminate high-frequency interference	1608

4.9.3 Memory Card Interface EMC and Reliability Design

SD card slot: used to expand storage capacity and store system files or data **TF card slot**: some small development boards use TF cards as storage media



model	Device Type	Use Location	effect	Encapsulation
ESD0524P	ESD	SD card interface	Surge, static electricity	DFN2510
ESD5V0APB	ESD	SD card interface	Surge, static electricity	SOT23

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