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# Flow Cytometer Electronic Electromagnetic Compatibility

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# 1. Interpretation of industry standards

# 1.1 International Industry Standards

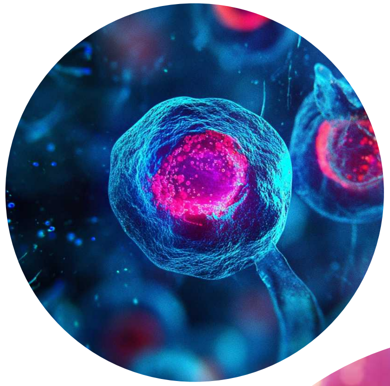
European Committee for Standardization EN 12885:1999 "Biotechnology. Performance Standard for Cell Lysers"

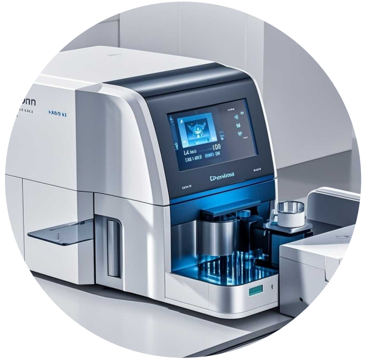
ASTM E3133-18 (American Society for Testing and Materials)

Performance Verification (ISO 20391, ASTM E3133)

Clinical Diagnostic Standardization (CLSI, ICCS/ESCCA)

Calibration and Quality Control (FDA, EU IVDR)





# 1.2 Domestic Industry Standards



Industry standards for flow cytometry, such as YY/T0588-2017, specify terms and definitions, product classifications, technical requirements, test methods, marking, labeling, instructions for use, packaging, transportation, and storage. These instruments are suitable for clinical use for quantitative analysis and sorting of biochemical and biophysical components on the surface and within the membranes of single cells or other non-biological particles (flow cytometers with sorting capabilities). [This information is available from official documents from the National Medical Products Administration (NMPA), ISO, or CLSI.]

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# 2. EMC test related requirements

# 2.1 Overview of EMC Test Items


EMC testing encompasses several key areas, ensuring the flow cytometer operates stably in complex electromagnetic environments without generating excessive electromagnetic interference.

Electromagnetic interference emission testing: This tests the electromagnetic energy emitted by the instrument during operation, including both conducted and radiated emissions.

Conducted emission testing: This tests the interference transmitted by the instrument through conductors such as power and signal lines.

Radiated emission testing: This tests the interference radiated into the surrounding area in the form of electromagnetic waves.

Immunity testing: Electrostatic discharge immunity tests the instrument's resistance to electrostatic discharge, while electrical fast transient (EFT) immunity tests the instrument's ability to withstand interference from fast transient pulses in circuits. These tests comprehensively assess the flow cytometer's electromagnetic compatibility.

## 2.2 Specific indicators and parameter requirements

**Radiated Emissions Test:**

Within a specific frequency range, the instrument's radiated emission intensity must be below specified limits. For example, in the 30MHz-1GHz frequency band, the radiated emission electric field strength may be required to not exceed a certain microvolt per meter to avoid interference with nearby wireless communication equipment and other medical devices.

**Electrostatic Discharge Immunity Test:**

The instrument is required to withstand different levels of contact discharge and air discharge: ±4kV for contact discharge and ±8kV for air discharge.

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# 3. Analysis of EMC pain points of flow cytometers

# 3.1 Electromagnetic interference affects stability



In real-world environments, flow cytometers are exposed to various sources of electromagnetic interference, including other medical equipment in hospitals (such as MRI and CT scans), communication base station signals, and power equipment.

This interference can distort instrument detection signals, leading to false positive or negative results, affecting physicians' diagnoses and research conclusions. Furthermore, electromagnetic interference can damage the instrument's electronic components, shortening its lifespan and increasing its operating costs.

# 4. Circuit design EMC solution

# 4.1 Grounding Technology Optimization

A hybrid grounding method is used, combining the advantages of single-point grounding and multi-point grounding. For the low-frequency signal part, single-point grounding is used to connect the points that need to be grounded in the circuit and equipment to a point that is defined as only one physical point as the ground reference point, reducing ground loop interference and improving circuit stability. For the high-frequency signal part, it is connected to the ground plane through a bypass capacitor to reduce the ground impedance and reduce the influence of high-frequency standing waves. When the wavelength of the circulating signal is less than 0.05λ, single-point grounding is used. If the length of the grounding wire reaches more than 0.05λ, multi-point grounding is used. According to the characteristics of different frequency signals in the flow cytometer circuit, the grounding method can be flexibly selected to effectively suppress electromagnetic interference.

# 4.2 Shielding Technology Application



For electric field shielding, metal shielding layers are placed between objects at different potentials within the instrument, such as metal shielding mesh around signal transmission lines, to reduce the induction of interference sources on the signal lines. The shielding layer uses a well-conducting conductor, ensuring sufficient strength and good grounding. This effectively increases the distance between the interference source and the induced object, reduces distributed capacitance, and brings the induced object closer to the ground plane, increasing its capacitance to ground, thereby reducing electric field interference.

For magnetic field shielding, a shield is constructed of high-permeability, thick material to surround the instrument's magnetic components or parts susceptible to magnetic field interference. The shield's magnetic shunting effect weakens the magnetic field within the shield, reducing the impact of magnetic field interference on the instrument's circuitry.

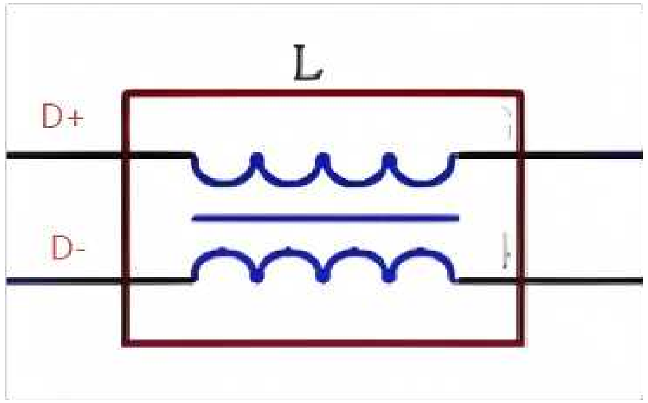
# 4.3 Filter Circuit Design

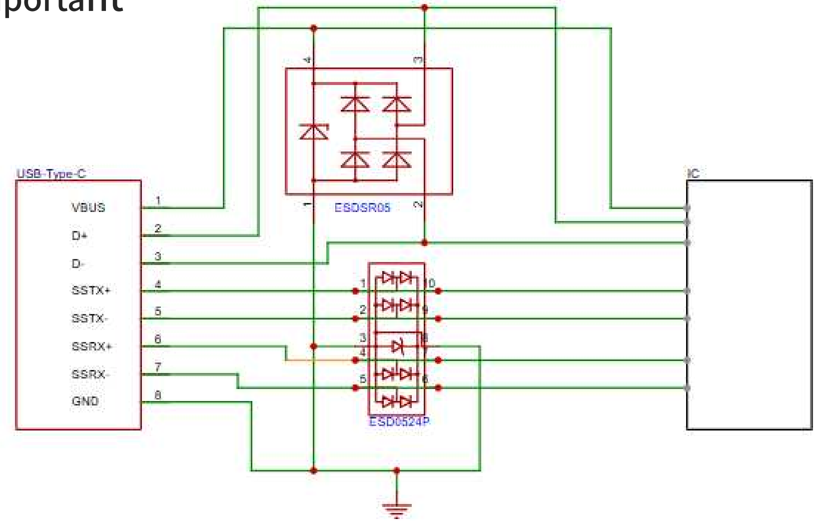
Design a filter circuit at the power input and output terminals, using a combination of common-mode inductors, differential-mode inductors, and capacitors. Common-mode inductors suppress common-mode interference, which occurs between the power grid and the neutral line; differential-mode inductors suppress differential-mode interference, which occurs superimposed on the line voltage's sine wave.

By properly selecting the inductor and capacitor parameters, such as the inductance and capacitance, the filter circuit achieves excellent attenuation characteristics for various types of interference within a specific frequency range. This effectively filters out interference from voltage drops, power outages, frequency offsets, electrical noise, surges, harmonic distortion, and transients, providing a stable, clean power supply for the flow cytometer circuitry and ensuring proper instrument operation.

## USB interface

The USB interface has high-speed data transmission capability and plug-and-play features, which makes it easy for users to connect and replace devices at any time, improves the convenience of using robots, and plays a key role in various robot application scenarios; high-speed data transmission (such as gene sequence data, mass spectrometry raw data), sequencers, mass spectrometers; all interfaces must pass the YY 0505 (EMC standard for medical electrical equipment) test, so common mode rejection is very important



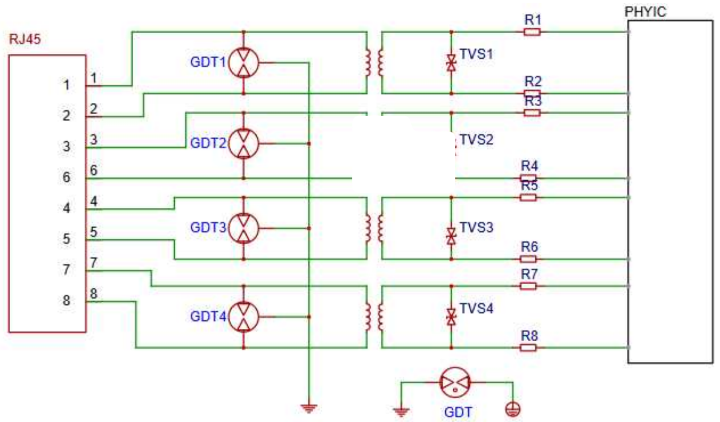

| model | Device Type | Use Location | effect | Encapsulation |
|---|---|---|---|---|
| ESD0524P | ESD | USB interface | Surge, static electricity | DFN2510 |
| ESDSR05 | ESD | USB interface | Surge, static electricity | SOT143 |
| CMZ2012A-900T | Common choke | USB interface | EMI | 2012 / 3225 |

# 4.4.2 Ethernet Interface EMC and Hot-Swap Reliability Design

## Ethernet interface:

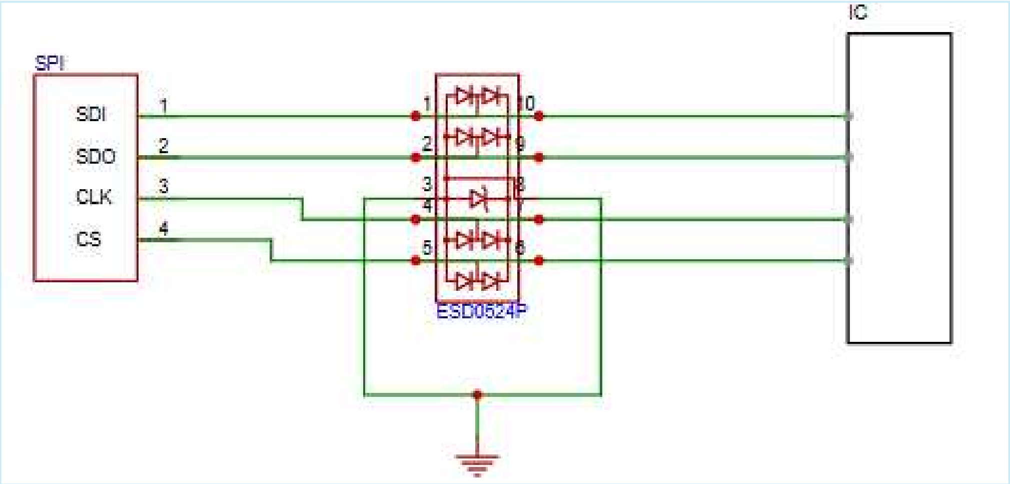
Ethernet port (RJ45): Supports wired network connections (common on intelligent robot motherboards).

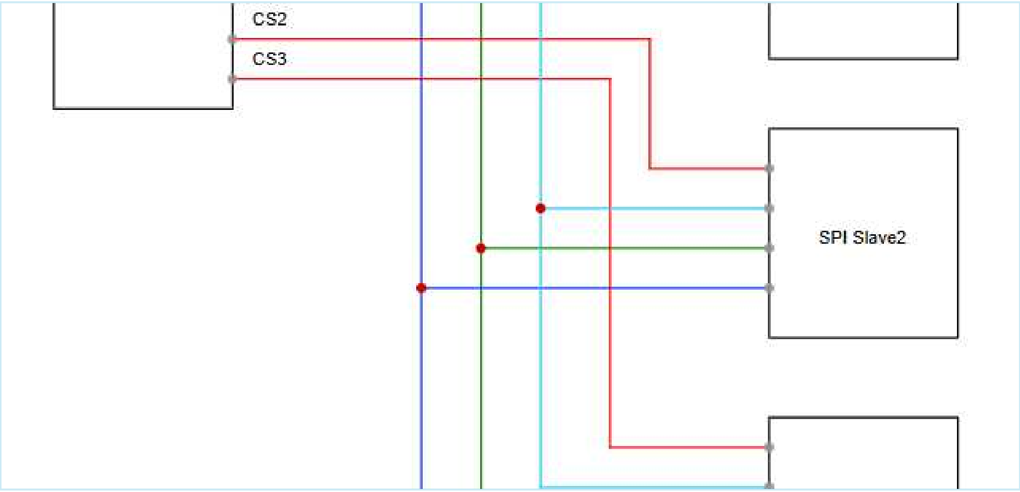
The Ethernet port provides a stable network connection for the robot, enabling remote control and data exchange. Through Ethernet, the robot can upload real-time working data to the cloud, receive remote commands, and implement intelligent remote operation. Its transmission speed can reach 1000Mbps or higher, meeting the high-speed, stable data transmission requirements of robots in industrial automation, intelligent logistics, and other fields.




| model | Device Type | Use Location | effect | Encapsulation |
|---|---|---|---|---|
| 3R090L | GDT | Ethernet interface | surge | 3RXXXL |
| 2R090L | GDT | Ethernet interface | surge | 2RXXXL |
| ESDLC3V3D3B | ESD | Ethernet interface | Surge, static electricity | SOD323 |

Some models are equipped with a touch screen control panel




| model | Device Type | Use Location | effect | Encapsulation |
|---|---|---|---|---|
| ESD0524P | ESD | SPI interface | Surge, static electricity | DFN2510 |
| ESDLC5V0D8B | ESD | SPI interface | Surge, static electricity | DFN882/1006, layout is easy |

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