AN6330

Application note

ASA-ML ESD protection and filtering

Introduction

The Automotive SerDes Alliance (ASA) was established to standardize SerDes connectivity for automotive applications. ASA is a nonprofit industry alliance comprising automotive industry and technology providers collaborating to define the specifications and infrastructure required for the automotive sector.

The objectives of the ASA are as follows:

1. Define specifications that enable interoperable implementations of the physical, data link, and transport layers for 15 meter coaxial and 10 meter shielded twisted pair (STP) channels with up to four in-line connectors.
2. Expand the ecosystem with requirements and complementary test specifications for harnesses, **electronic control units (ECUs)**, and additional functionalities.
3. Support the development of a new physical layer specification tailored for automotive use cases.
4. Continuously identify and address gaps related to the implementation of SerDes-based communication in automotive applications.

ASA motion link (ASA-ML) is the brand name for all ASA technologies and devices. You can see the FAQ ASA web site.

This application note provides an overview of the electrical and electromagnetic constraints in the automotive environment. It also includes a summary of the ASA-ML physical layer (PHY) and the specifications relevant to electrostatic discharge (ESD) protection and filtering devices.

Finally, the STMicroelectronics portfolio of ESD protection and filtering solutions for ASA-ML is presented.

Related links

You can see the FAQ ASA web site.

1 Electrical hazards in the automotive environment

The automotive environment presents various electrical hazards. These hazards, such as electromagnetic interference (EMI), electrostatic discharge (ESD), and other electrical disturbances, are generated by components like ignition systems, relay contacts, alternators, injectors, and high dV/dt or dI/dt during normal operation.

These hazards can occur in the following ways:

- Directly: In the wiring harness due to conducted disturbances
- Indirectly: In electronic modules through radiation and coupling.

The generated hazards can impact electronics in two ways, depending on the environment:

- On the data lines
- On the supply rail wires.

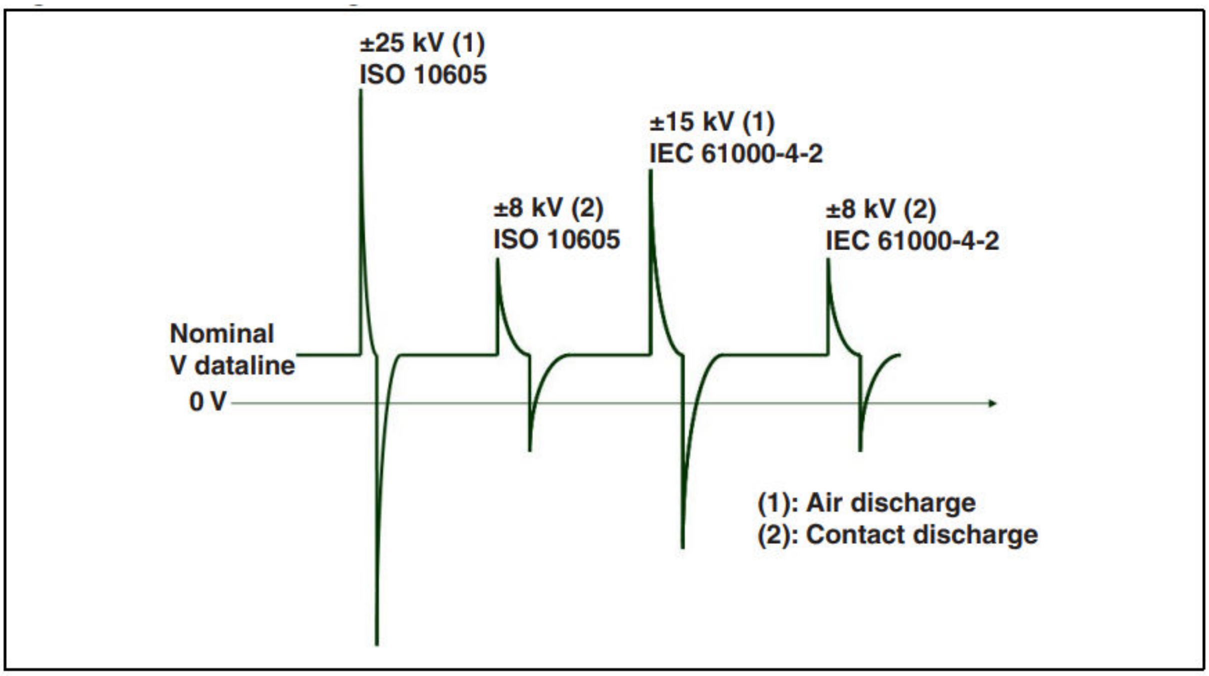
This section focuses only on the impacts on the data lines. For impacts on supply lines, refer to *AN2689 - Protection of automotive electronics from electrical hazards: Guidelines for design and component selection.*

1.1 Propagation of electrical hazards on data lines

Transients generated on data lines are primarily electrostatic discharge (ESD) surges. These surges have low energy but exhibit a very high dV/dt, which generates a strong electromagnetic field. The *ISO 10605* and *IEC 61000-4-2* standards define ESD surges. Affected data lines include communication lines such as media transfer lines, video links, data buses, sensor data lines, and control lines.

The Figure 1 illustrates the surge forms of hazards that occur on data lines.

Figure 1. Types of surges on data lines



The ESD surge test is applied to a complete system to simulate ESD events, such as those caused by human body contact or connector plug-ins on an electronic module.

1.2 Standards for the protection of automotive electronics

Several standards bodies, such as the *society of automotive engineers (SAE)*, the *automotive electronics council (AEC)*, and the *international organization for standardization (ISO)*, describe the hazards indicated above.

ISO 10605 and *ISO 7637-3* are the most important automotive standards regarding electrical hazards.

2 ASA-ML PHY

2.1 Physical medium attachment (PMA)

The ASA-ML PMA consists of one coaxial line (Z_0 = 50 Ω) or one differential lane (Z_{0DIFF} = 100 Ω), AC-coupled. It is a bidirectional link. Additionally, it can carry a power supply.

The schematic below illustrates setups with shielded twisted pair (STP) and coaxial cables:

Figure 2. **STP point-to-point setup**

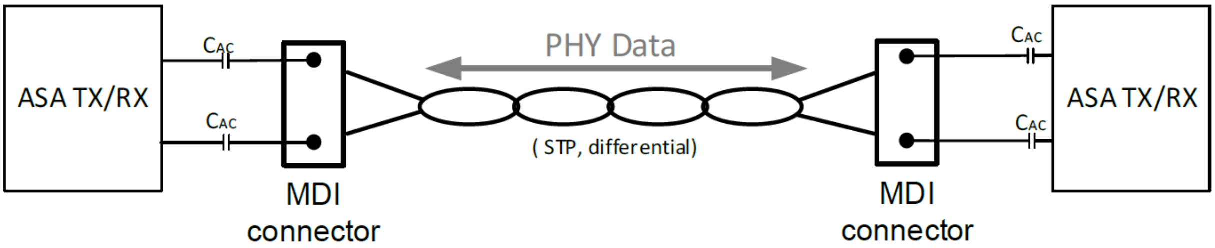
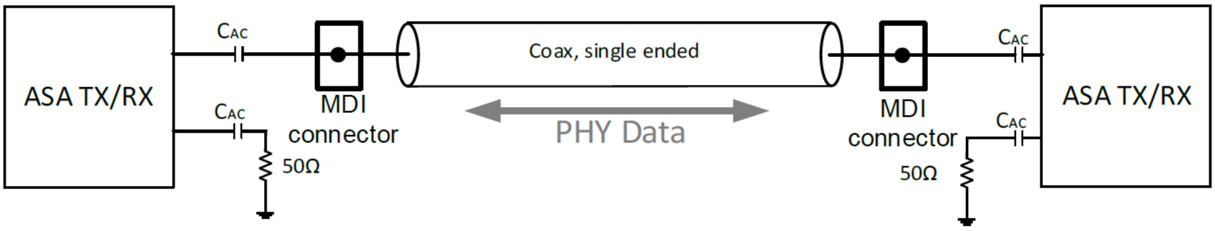


Figure 3. **Coaxial point-to-point setup**



2.2 Data rate

The Table 1 shows five speed grade configurations with downstream and upstream data rates:

- Up to 16 Gbps for downstream
- Up to 4 Gbps for upstream
- PAM2 or PAM4 modulations are used.

Table 1. **ASA physical Layer generation 2020 Speed Grade overview**

Speed grade	Downstream			Speed grade	Upstream		
	Line rate	Payload data rate DLP	Baud rate / Modulation format		Line rate	Payload data rate DLP	Baud rate / Modulation format
1	2 Gbps	≥ 1.8 Gbps	2 G / PAM2	1	2 Gbps	≥ 50 Mbps	2 G / PAM2
2	4 Gbps	≥ 3.6 Gbps	4 G / PAM2	1/2	2 Gbps (mandatory) 4 Gbps (optional)	≥ 50 Mbps ≥ 100 Mbps	2 G / PAM2 4 G / PAM2
3	8 Gbps	≥ 6.4 Gbps	8 G / PAM2	1/2			
4	12 Gbps	≥ 9.7 Gbps	6 G / PAM4	1/2			
5	16 Gbps	≥ 13 Gbps	8 G / PAM4	1/2			

2.3 Nominal transmitter output levels

Transmission levels are defined as follows according to grades:

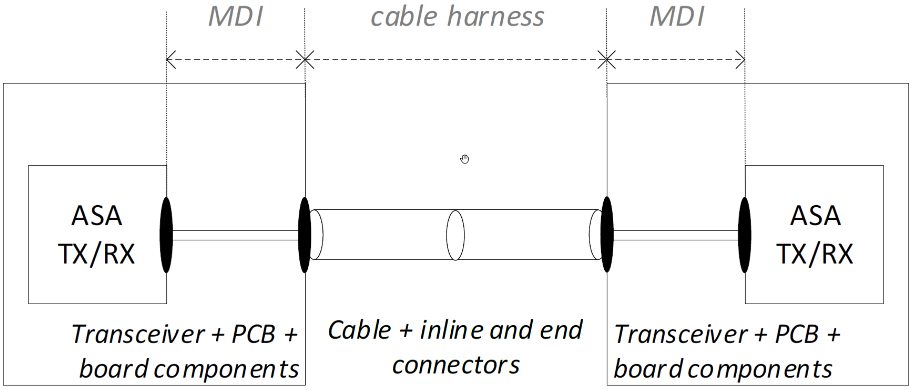
- For grades 1 and 2:
  - **V = 0.7 V_{PP}** for differential link
  - **V = 0.35 V_{PP}** for coax link.
- For grade 3:
  - **V = 1 V_{PP}** for differential link
  - **V = 0.5 V_{PP}** for coax link.
- For grades 4 and 5:
  - **V = 1.2 V_{PP}** for differential link
  - **V = 0.6 V_{PP}** for coax link.

For a signal without offset, the minimum voltage related to ground is **-0.3 V**. This allows the usage of a unidirectional TVS device.

2.4 Media-dependent interface (MDI) specifications

Protection and filtering devices are implemented between connector and SerDes IC: they are part of MDI.

Figure 4. Parts of ASA channel definition



ASA-ML define *S-Parameter* templates for MDI:

- Maximum values for insertion loss (S_{21} or S_{DD21}). See Figure 5
- Minimum values for return loss (S_{11}/S_{22} or S_{DD11}/S_{DD22}). See Figure 6.

Figure 5. Maximum values for insertion loss

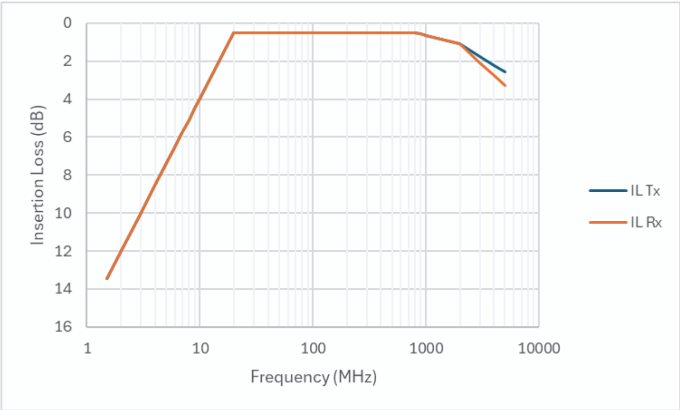
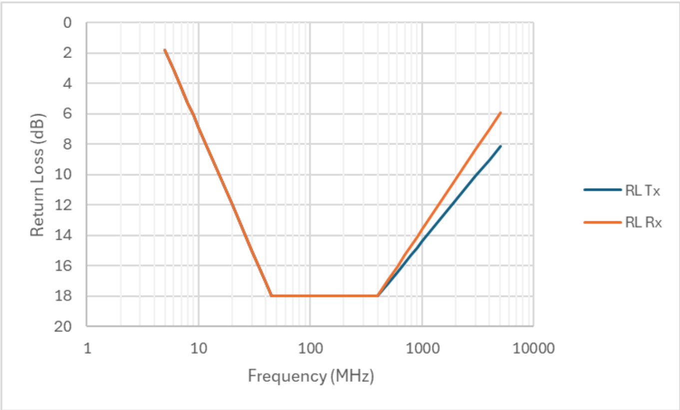


Figure 6. Minimum values for return loss



Protection and filtering devices must comply with these specifications.

3 ST offers for ESD protection

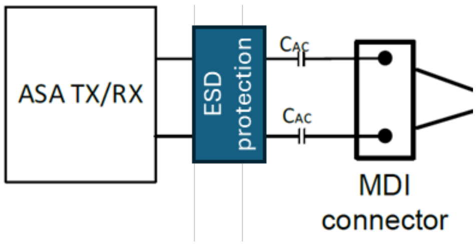
In ST's product portfolio, you can find an ESD protection device compatible with the ASA-ML standard.

For ESD protection, placement at the connector is always preferred. An AC capacitor cancels the DC bias voltage, so only the data signal levels need to be considered. The tracks between the ESD protection device and the line to be protected must be as short as possible to minimize the inductive effect on the clamping voltage value. The same rule applies between the protection device and the ground plane.

The track's parasitic inductance adds extra voltage to the clamping voltage of the ESD protection device.

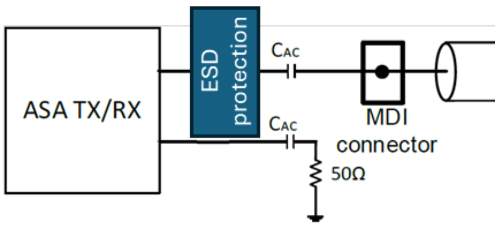
For more details, see *AN5686 - PCB layout tips to maximize ESD protection efficiency*.

Figure 7. ESD protection implementation on a differential system



Our ESD protections devices can be used on differential lines as well as on coaxial lines.

Figure 8. ESD protection implementation on a single-ended system



According to *ASA-ML* characteristics, shown above, ESD protection requirements are:

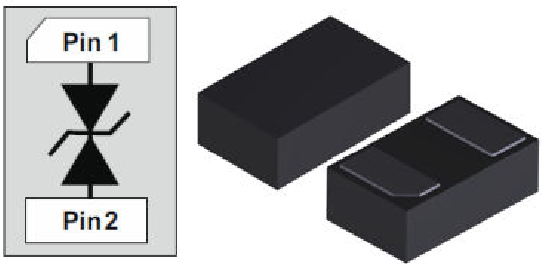
- Unidirectional / Bidirectional devices are suitable
- Compliant with *ASA-ML MDI IL* and RL templates
- $V_{RM} \geq 0.3$ V (maximum voltage is 0.6 V_{PP})
- ESD robustness complies with *ISO 10605* and *IEC 61000-4-2* standards.

Also, to respect insertion loss template, the package should not be SOT323-3L & SOT23-3L. Indeed, internal long wire bonding can decrease the resonance frequency, so leading to insertion loss is not compliant with *ASA-ML MDI* requirements.

ESDAXLC6-1BT2Y is a single-line ESD device designed for high-speed lines protection.

This part is on NRND status following PTN15673 related to new front-end location and technology, with deliveries secured till H2 2026. Development of a new product using this upgraded technology with reference *ESDXLC6-1BT2Y* is planned.

Figure 9. ESDAXLC6-1BT2Y functional schematic and package (0402)



Its line capacitance is lower than 0.5 pF and it provides a high robustness against ESD stress.

Below figures show *ASA-ML MDI* templates and *ESDAXLC6-1BT2Y* measurements:

- For insertion loss (S_{21})
- For return loss (S_{11}).

ESDAXLC6-1BT2Y is compliant with *ASA-ML MDI* requirements.

Figure 10. **ESDAXLC6-1BT2Y S_{21} versus ASA-ML MDI requirements**

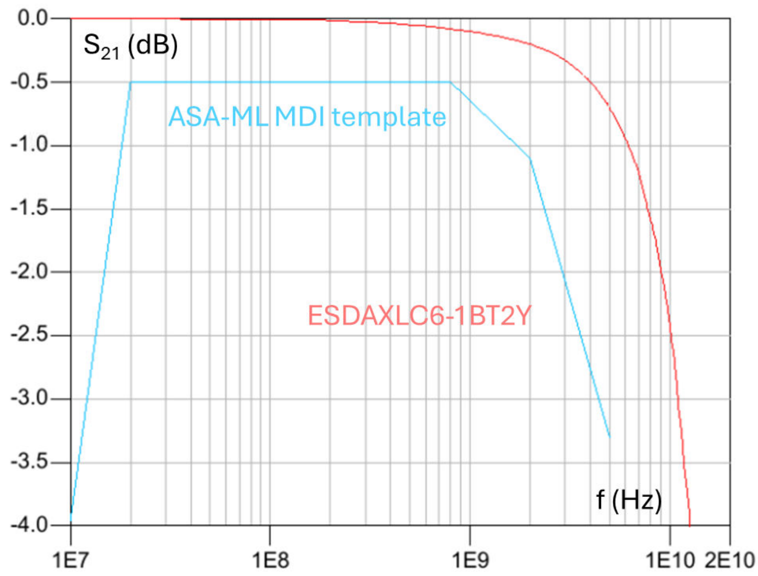
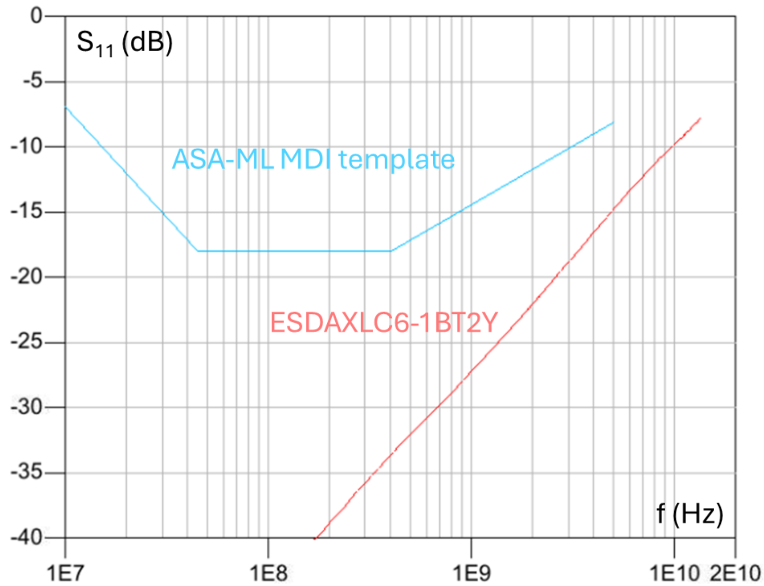


Figure 11. **ESDAXLC6-1BT2Y S_{11} versus ASA-ML MDI requirements**



ESDAXLC6-1BT2Y datasheet can be downloaded from st.com website.

4 ST offering for filtering and protection (ECMF)

An ECMF is a common-mode filter that integrates an ESD protection die. This integration allows for space savings compared to using discrete common-mode filters (CMFs) and discrete ESD protection components. Additionally, the performance of ECMFs includes ESD protection, which must be added to the CMF performance in the case of discrete implementations.

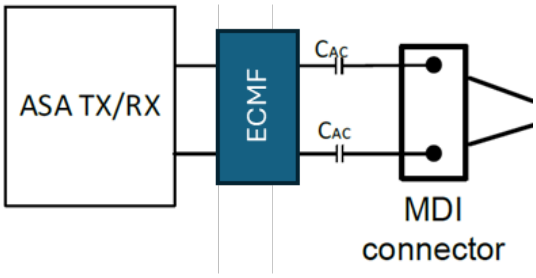
Why use a common-mode filter?

The automotive environment increasingly includes high-speed lines and antennas. These high-speed transmission lines generate frequency harmonics. To ensure good sensitivity of the RF receiver, the system must limit emissions at RF receiver frequencies. High-speed differential links can radiate at these frequencies, and emissions can be attenuated by using a common-mode filter. This approach prevents the antenna desense phenomenon. For more details, see *AN4356 - Antenna desense on handheld equipment*.

For additional information on ECMFs, refer to *AN4511 - Common-mode filters*.

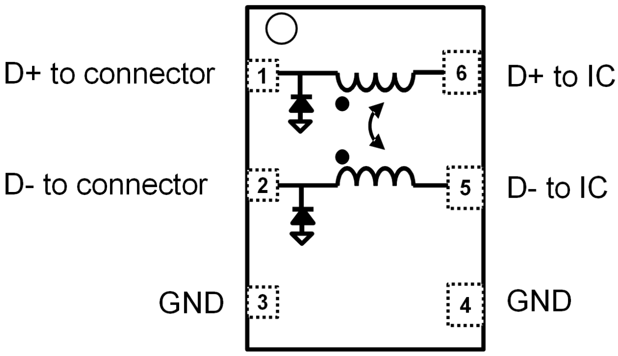
ECMF must be placed after the capacitor and as close as possible to the connector for the same ESD safety reasons explained before.

Figure 12. **ECMF implementation on a differential system**



The *ECMF2-40A100M6Y* is a one-pair common-mode filter that also integrates ESD protection. Figure 13 is the functional diagram:

Figure 13. **ECMF2-40A100M6Y functional diagrams**



The performance of the *ECMF2-40A100M6Y* is compared with ASA-ML MDI requirements in Figure 14.
As it is a differential link, S_{DD21}, S_{DD11}, and S_{DD22} are plotted.

Figure 14. ECMF2-40A100M6Y S_{DD21} versus ASA-ML MDI requirements

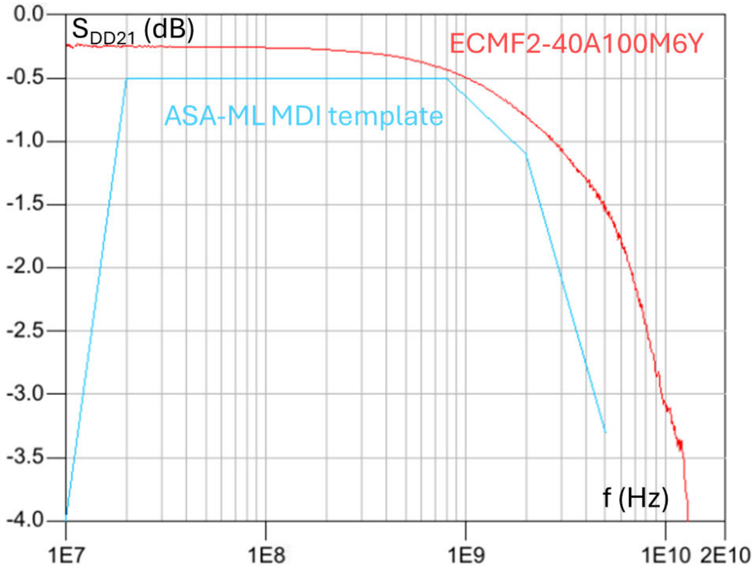
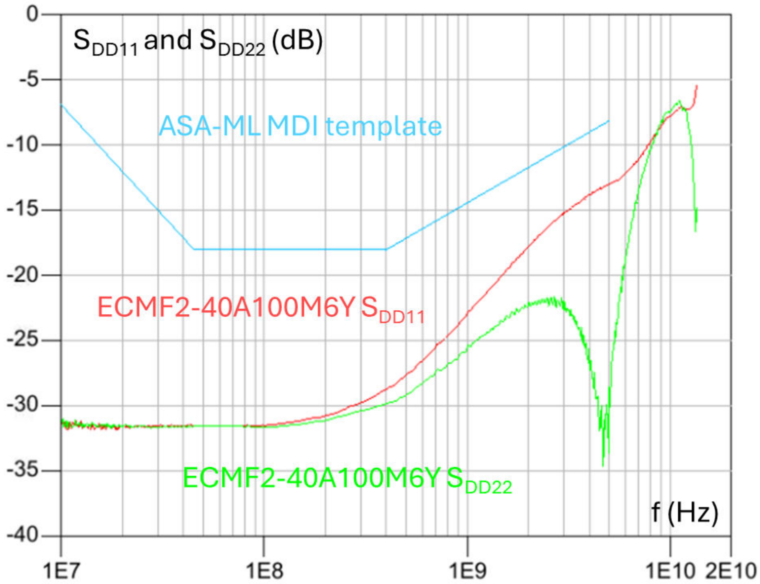


Figure 15. ECMF2-40A100M6Y S_{DD11} and S_{DD22} versus ASA-ML MDI requirements



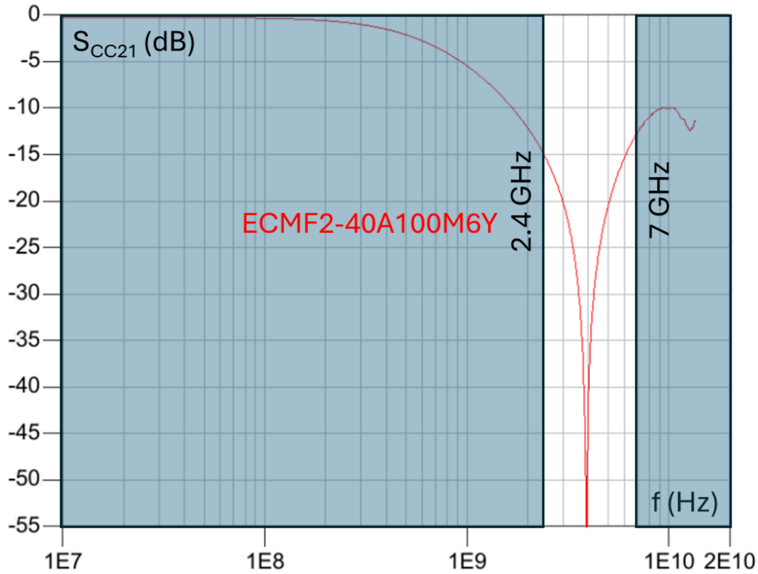
These figures demonstrate that the *ECMF2-40A100M6Y* complies with *ASA-ML MDI* requirements.

Common-mode rejection

The Figure 16 shows that the common-mode rejection of the *ECMF2-40A100M6Y* is optimized to reject noise for the following standards:

- Bluetooth (2.4 GHz)
- Wi-Fi 2 (2.4 - 2.5 GHz)
- Wi-Fi 5 (5 - 6 GHz)
- Wi-Fi 6, 7, 8 (6 - 7 GHz)
- V2X (5.9 GHz).

Figure 16. **Common-mode rejection of the ECMF2-40A100M6Y**



Protection features

The ECMF also includes protection features. For detailed information, refer to the datasheet, which can be downloaded from the ST website at: ECMF2-40A100M6Y.

5 Conclusion

After detailing the requirements of the *ASA-ML* specification applicable to ESD protection and filtering devices, compliant ST solutions are presented:

- *ESDAXLC6-1BT2Y* for ESD protection
- *ECMF2-40A100M6Y* for common-mode filtering and ESD protection.

Both components are automotive grade and in mass production. They ensure the following:

- Immunity to external surges
- Low radiation allows maintaining good sensitivity of RF receivers.

Revision history

Table 2. Document revision history

Date	Revision	Changes
22-Aug-2025	1	Initial release.

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