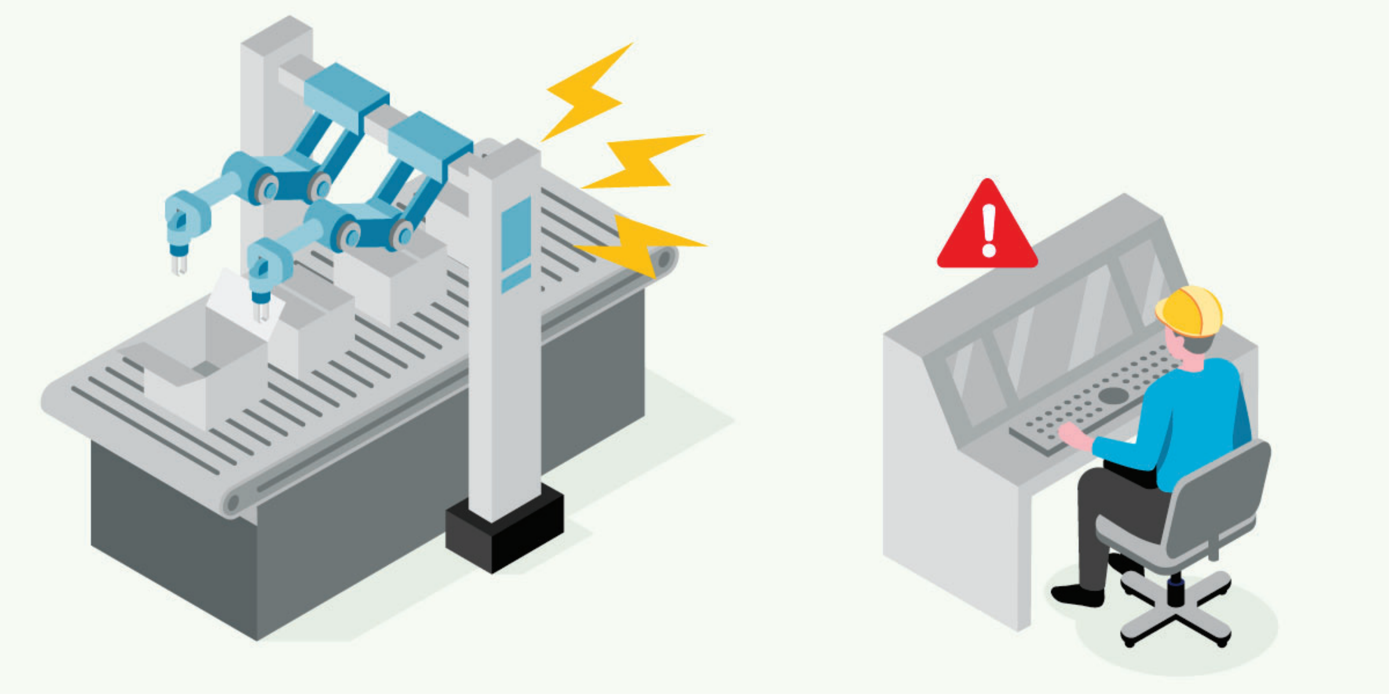
Articles



Immunity improvement method for industrial equipment

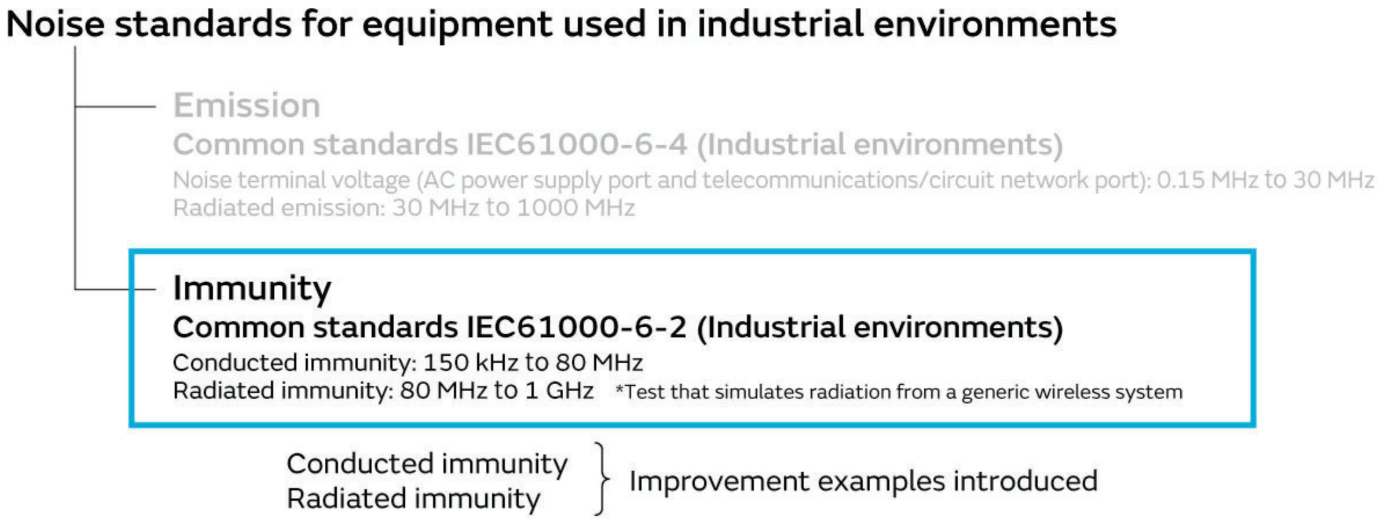
17/12/2024

Noise Suppression Products   EMI Suppression Filters   Industrial equipment   Robot

1. Introduction

Recent years have seen remarkable development in automation technology within manufacturing sites. As a result, experts anticipate an increase in noise problems in facilities utilizing industrial equipment such as robots and their peripheral equipment.
One such issue involves malfunctions caused by external noises from other equipment or internal circuit-generated sounds within the machinery itself. Consequently, the concern over immunity to noise—that is, resistance to noise—has become increasingly relevant.

This article introduces examples of immunity improvement for industrial equipment.
Currently, there are no official standards that regulate immunity for industrial equipment.
Therefore, we built an immunity evaluation environment with reference to the IEC61000-6-2 common standard for industrial environments. We examined the immunity improvement method using an evaluation board for industrial equipment design applications, as well as improvement for conducted immunity and radiated immunity as stipulated in IEC61000-6-2.



2. Example introduction

2-1. Conducted immunity - test setup

We will now discuss the test setup we have built to examine immunity improvement.

We connected two cables to an evaluation board.

A terminal that detects (or outputs) signals is connected to one end of the cable as an auxiliary device. The signals detected by the auxiliary device are transmitted to the evaluation board via the cables.

An A/D converter is mounted on the evaluation board.

We compared the signals from the auxiliary device (analog signals at a sine wave of 100 Hz) with a comparator to check for errors.

Specifically, we compared the voltage amplitude and phase of the analog signals "+" and analog signals "-".

The comparison results are displayed on an external display.

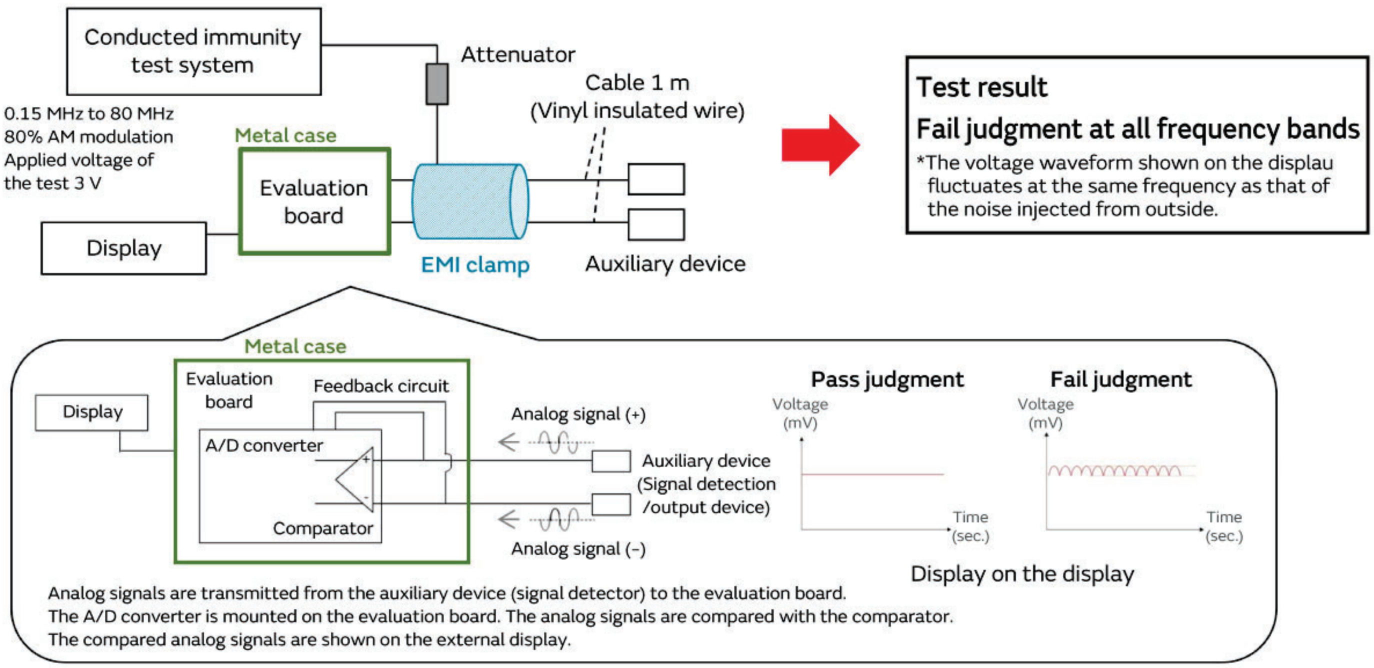
The criteria for determining whether an error occurred during the immunity test are as follows:

1. If the voltage waveform shown on the display remains constant over time, it is deemed that no error has occurred (pass).

2. Conversely, if there is any change in the voltage waveform over time, it is considered an error (fail).

The results of the conducted immunity test revealed that errors occurred at all test frequencies (150 kHz to 80 MHz).

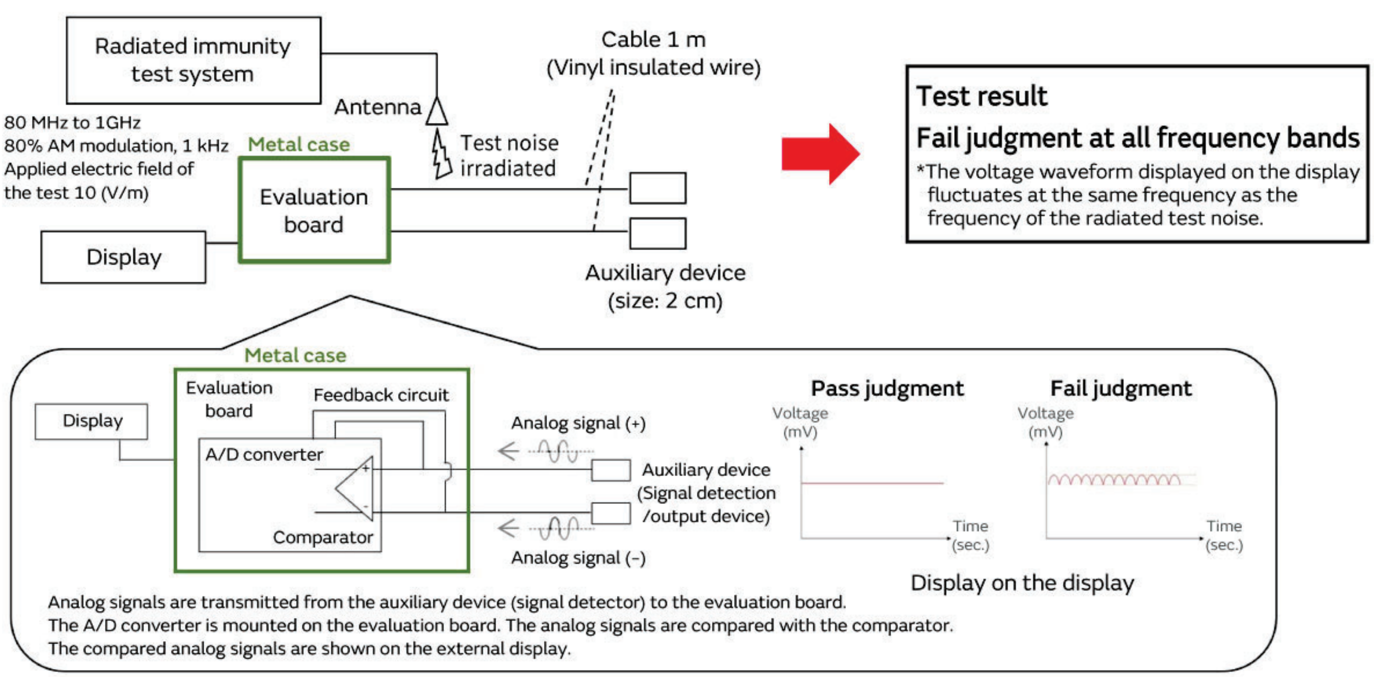
When observing the voltage waveform, we confirmed that it fluctuates over time in conjunction with the frequency and phase of the noise injected from outside.



2-2. Radiated immunity - test setup

Next, we will present an example of how to improve radiated immunity. We utilized the same evaluation board introduced in the conducted immunity example, and the method for judging error occurrences remains consistent with that example.

The results of the radiated immunity test revealed that errors occurred at all test frequencies (80 MHz to 1 GHz).
When observing the voltage waveform displayed on the external display, we confirmed that it fluctuates over time in conjunction with the frequency of the noise injected from outside. This phenomenon was the same as during the conducted immunity test.



2-3. Investigation of the conducted immunity mechanism

We investigated the mechanism by which errors occur during the conducted immunity test.
The mechanism consists of the following (1) to (4).

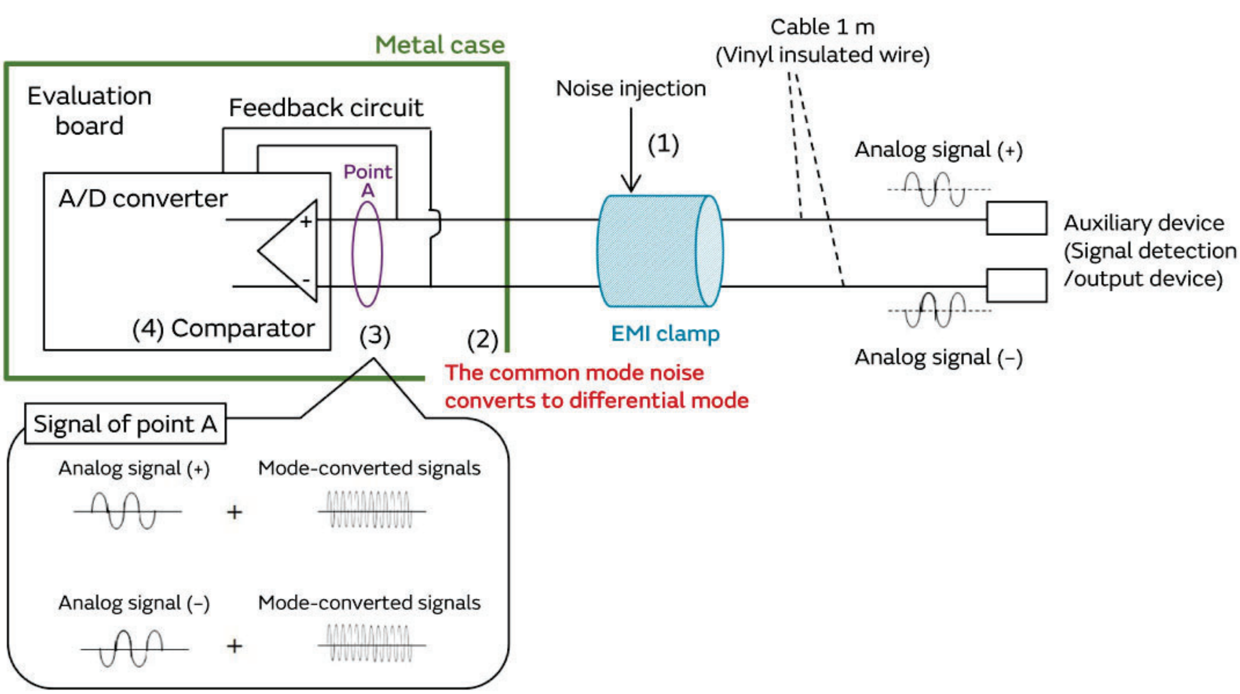
(1) We mount an EMI clamp to the cable and then inject a prescribed noise from the EMI clamp in the conducted immunity test.
In other words, we evaluate the malfunction status when we inject noise in the common mode into the cable.

(2) The noise injected by the EMI clamp is common mode. On the other hand, the communication signals are differential mode.
Ideally, differential mode and common mode exist independent of each other. However, mode conversion occurs in an actual board.
In general, we often see cases in which analog signals are affected by external noise, with that then leading to malfunctions.
In this example, the common mode noise injected by the EMI clamp is converted to differential mode due to a characteristic impedance mismatch in the cable and other parts.

(3) The analog signals and the signals for which the externally inject noise has been mode converted are superimposed at point A (superposition principle).

(4) When we compared the voltage amplitude and phase of the signals with the comparator, unnecessary signals generated by the mode conversion remained.
Therefore, it is believed that the voltage waveform changed over time and an error occurred.

We set a noise improvement guideline to reduce the common mode noise that flows in from the cable based on these investigation results.



(1) Noise is injected through the two cables into the EMI clamp (noise is injected in common mode)

(2) Common mode noise is converted to differential mode

(3) The analog signals and the signals for which the injected noise has been mode converted are superimposed at point A

(4) The signals for which common mode noise has been mode converted remain in the comparator

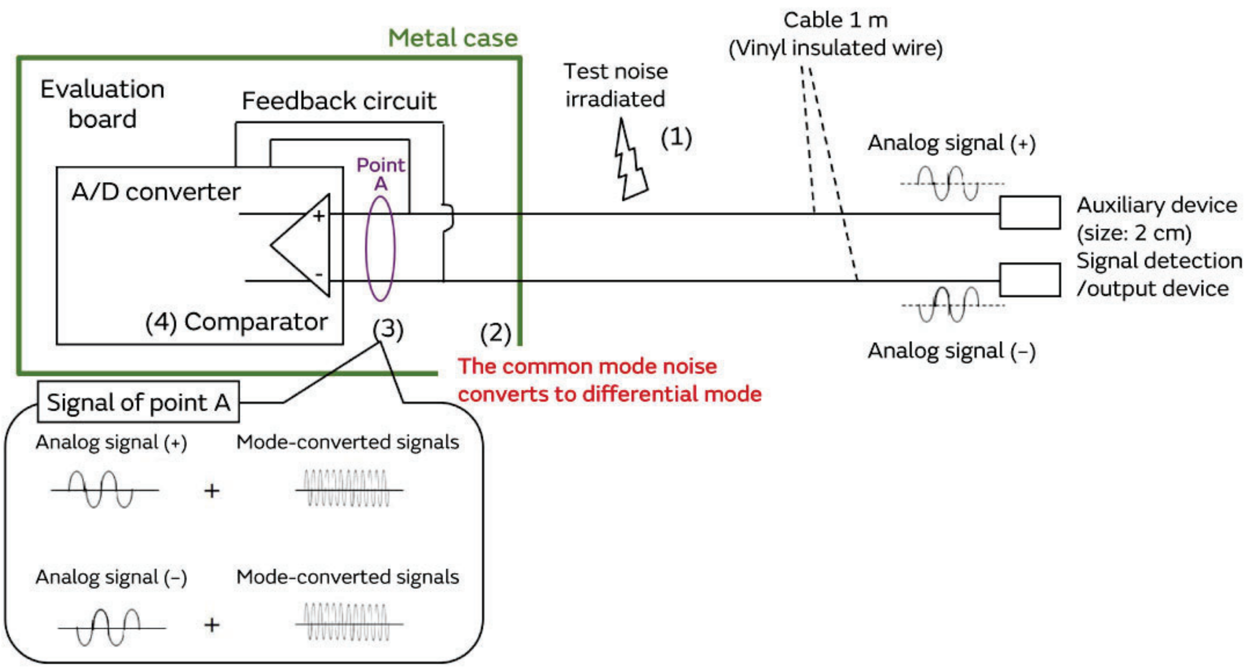
Noise improvement guidelines

Reducing the common mode noise that flows in from the cable results in a reduction in the signals that convert to differential mode

2-4. Investigation of the radiated immunity mechanism

Similarly, we investigated the mechanism by which errors occur during the radiated immunity test.
That general mechanism was the same as in the previously conducted immunity test.
The test noise irradiated from the antenna couples to the cable in common mode ((1) in the figure below).
We learned that the common mode noise enters inside the board and then the error occurs ((2), (3), and (4) in the figure below).
We set a guideline to reduce the common mode noise that flows in from the cable in the same way as with conducted immunity for noise improvement as well.

Supplementary information on the irradiation of test noise ((1) in the figure below):
The test noise is irradiated to the metal case, cable, and auxiliary device respectively.
We placed an evaluation board inside the metal case as a prerequisite during the test. Therefore, the test noise emitted from the antenna couples to the cable and auxiliary device in common mode.
The size of the auxiliary device is about 2 cm. We found it to be a reasonable assumption that the impact of the noise was small.
Accordingly, we learned that the test noise mainly couples to the cable.



(1) The test noise emitted from the antenna couples (mainly) to the cable in common mode
(2) The common mode noise converts into differential mode
(3) The analog signals and the mode-converted signals superimpose at point A
(4) The signals for which the common mode noise has been mode converted remain in the comparator

Noise improvement guidelines

Reducing the common mode noise that flows in from the cable results in a reduction in the signals that convert to differential mode

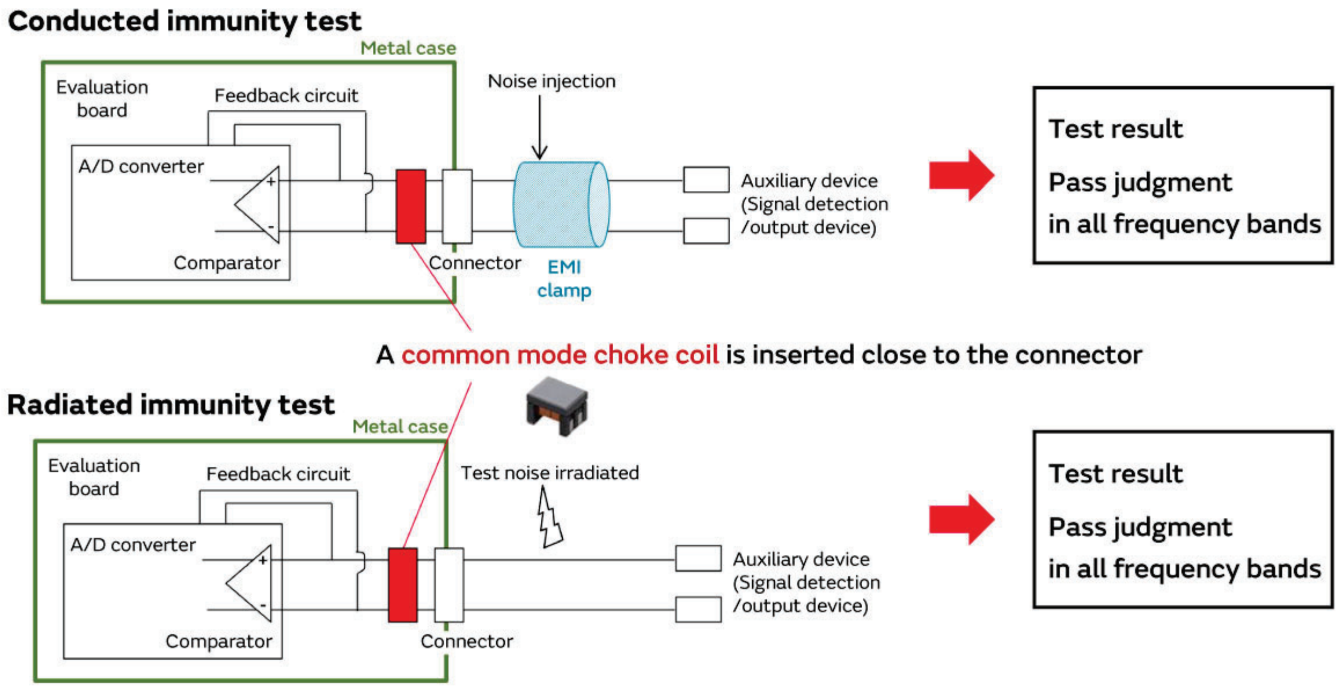
2-5. Noise improvement plan

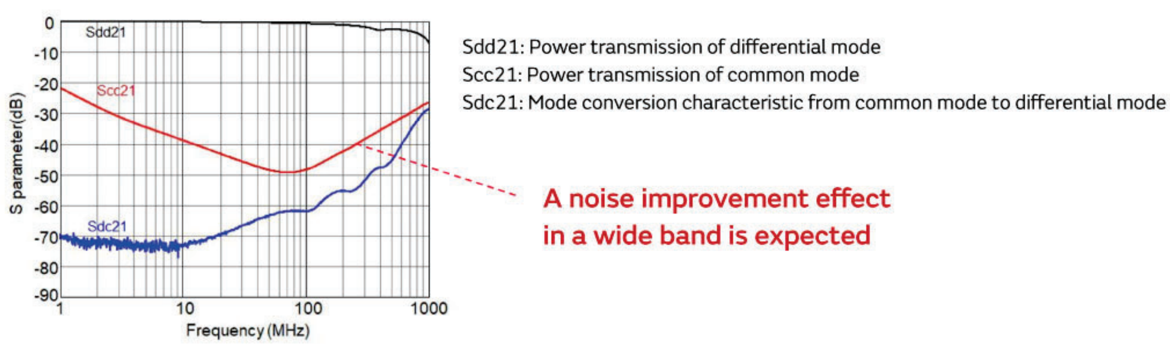
We implemented noise improvement according to the aforementioned noise improvement guidelines.
We confirmed that the same improvement was effective for both conducted and radiated immunity in this example.

We inserted a common mode choke coil close to the connector on the analog signal line of the evaluation board.
We used our part number DLW32MH101XK2 for the common mode choke coil.
We confirmed that errors do not occur at all the test frequencies in both the conducted and radiated immunity tests after we implemented the noise improvement.

Here, we give some points to consider when selecting a common mode choke coil.

- In essence, it is best that the signals that should be transmitted are fully transmitted. The Sdd21 power transmission of differential mode in the frequency of the communication signals is ideally 0 dB.
- It is best for the Scc21 power transmission of common mode to be small in the frequency band of the injected or irradiated noise (conducted immunity: 150 kHz to 80 MHz / radiated immunity: 80 MHz to 1 GHz).
- Analog signals are liable to be affected by external noise. Therefore, it is necessary to reduce the mode-converted signals as far as possible. In other words, it is best for the Sdc21 mode conversion characteristic to be small.





Appearance	Part number	Size	Rated current
	DLW32MH101XK2	L3.2 × W2.5 × T2.5 (mm)	100 mA

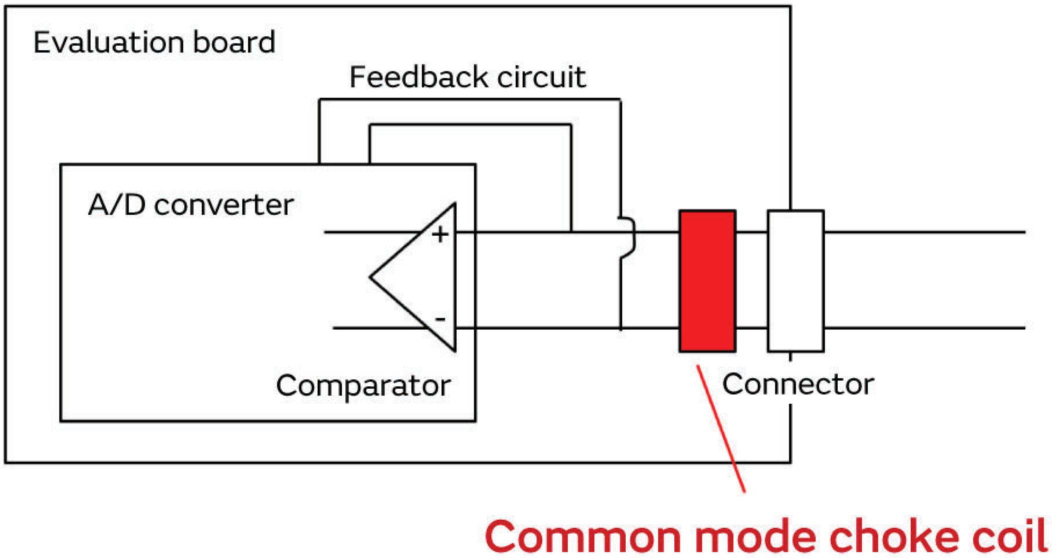
3. Summary

We evaluated conducted and radiated immunity using an evaluation board for industrial equipment. We learned the following.

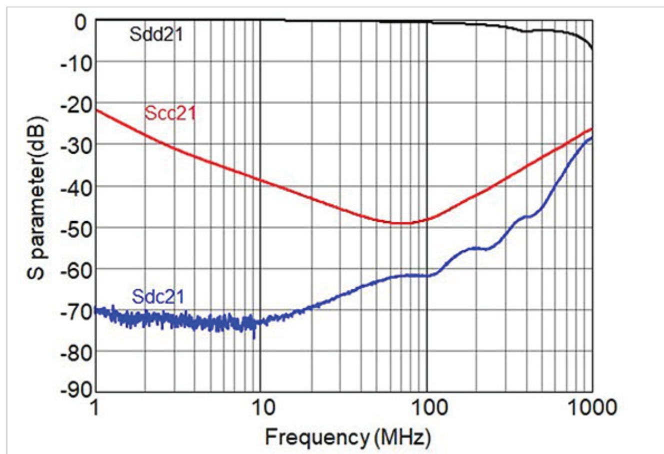
- Analog signals are liable to be affected by external noise.
- Immunity test noise is injected or irradiated in common mode. If common mode noise is converted to differential mode, the IC is likely to misrecognize the signal.

We confirmed that no errors occurred during both immunity tests by inserting a common mode choke coil in the analog signal line.

Noise improvement plan



This is a filter that attenuates common mode noise. It has an excellent noise removal effect over a wide frequency band.



Part number	Size	Rated current	Rated voltage	Operating temperature range
DLW32MH101XK2	L3.2 × W2.5 × T2.5 (mm)	100 mA	50 V	-40°C to 125°C

For more details about DLW32MH101XK2

Other Links

- Robot Emission Suppression Measures-1 (1/4)
- Robot Emission Suppression Measures-2 (2/4)
- Robot Emission Suppression Measures-3 (3/4)
- Robot Emission Suppression Measures-4 (4/4)

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DLW32MH101XK2

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