Technical Report

Technology of Thin-Film Common Mode Filters with Built-in ESD Protection

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1. Introduction

Recently, the signal frequencies of mobile phones have been further increased, accompanying the increase in information. Where LVDS*1 or MDDI*2 have generally been used as internal interfaces for transferring images up until now, terminals adopting MIPI*3, which is capable of further increasing processing speeds, have begun to appear on the scene.

In addition, where USB2.0 has been used as an external interface, HDMI1.4 and USB3.0, introduced last year, include microminiature connectors among their specified connectors, presumably for mobile phone use, and it can be expected that small devices equipped with theses interfaces will appear more often in the future. In the area of high-speed interfaces, ESD resistance is decreasing, due to the decrease in capacity accompanying the miniaturization of IC devices. Therefore, ESD measures will be necessary to prevent IC damage due to electrostatic discharges (ESD) generated by causes such as the plugging in and pulling out of cables.

On the other hand, where mobile phones are concerned, it is important to take EMC measures for high-frequency bands over 1GHz, since they tend to be equipped with applications such as wireless LAN, Bluetooth or GPS as well as 3G communication systems of GSM/W-CDMA or CDMA2000.

Considering the abovementioned backgrounds, it can be said that ESD/EMC measures will become increasingly important in the future, accompanying the further sophistication of mobile phones. Although it is generally ideal to use both a common mode filter as an EMC measure and an ESD protection device as an ESD measure where mobile devices are concerned, reductions in the number of mounted parts and the space they consume are also required, accompanying the sophistication/downsizing of mobile phones.

*1 LVDS : Low Voltage Differential Signaling
*2 MDDI : Mobile Display Digital Interface
*3 MIPI : the Mobile Industry Processor Interface

Therefore, we came up with the idea that it would be effective to bundle the two functions together in order to reduce the number of mounted parts and the space they consume.

Considering this, TDK-EPC Corporation combined the function of an ESD protection device together with the thin-film common mode filter we have been manufacturing and selling for some time, and made possible the implementation of a noise countermeasure and an ESD measure simultaneously using a single device.
In this report, we will introduce the technologies regarding the thin-film common mode filter with built-in ESD protection device function.

2. Product summary

TDK-EPC Corporation has been commercially producing a thin-film common mode filter with a size of 1.25mm×1.0mm, which is responsive to a single pair differential signal and is compatible with high-speed signals such as HDMI, for some time (product name TCM1210H-900-2P). The product to be introduced here is a thin-film common mode filter equipped with an ESD protection device function (product name TCE1210-900-2P), where the function of an ESD protection device has been added to the TCM1210H. For this reason, the transmission characteristics of differential signals are the same as those of the TCM1210H, capable of producing the effect of removing common mode noises without influencing high-speed signals.

In addition, the external dimensions are the same as those of the existing TCM1210H, as shown in Figure 1, and a terminal has been added in order to connect it with a GND for ESD protection. A photograph of the TCE1210's external appearance is shown in Photo 1.
Whereas the TCE1210 is responsive to a single pair differential signal, we have also commercialized an array type TCE1608 (responsive to a 2-pair differential signal) apart from the TCE1210. Although HDMI transmits 4 types of differential signals, two TCE1608s will be sufficiently capable of providing EMC/ESD measures.

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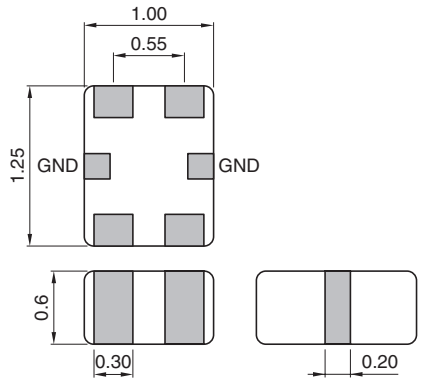
Figure 1 External dimensions



Dimensions in mm

Photo 1 External appearance

3. Electrical characteristics

3-1. EMC suppression effect

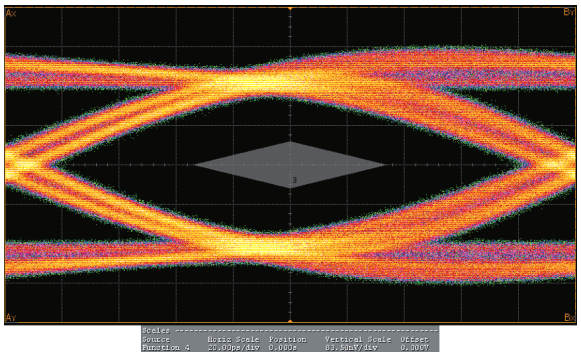
The functions of a common mode filter and an ESD protection device have been bundled together in the TCE1210, making it possible to implement EMC/ESD measures simultaneously. We will now compare the transmission waveforms (eye patterns) when actual high-frequency signals were transmitted and the noise radiation reduction effects, with the aim of confirming the effects of the common mode filter function. We used a 2.5GHz (5Gpbs) USB3.0 signal as the signal for transmission.

First, the waveforms are shown in Figure 2. When comparing the waveform appearing when not using any filter with the waveform appearing when using the TCE1210, no distortions are found in the waveform, proving that almost no influence is exerted on the differential transmission signals.

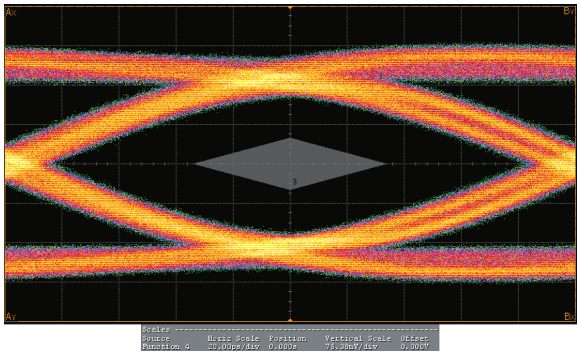
Compared to this, a standard common mode filter cannot be used for high-speed signals such as USB3.0, since the waveform that appears is greatly distorted. The results also prove that the TCE1210 is a usable part for high-speed differential interfaces such as USB3.0.

Figure 2 Transmission waveform of USB3.0 (Eye pattern evaluation)

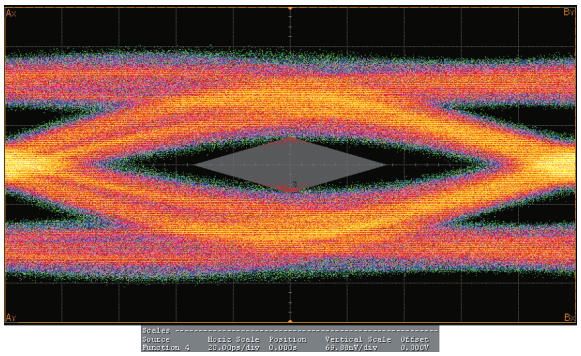
No filter



When using TCE1210-900-2P



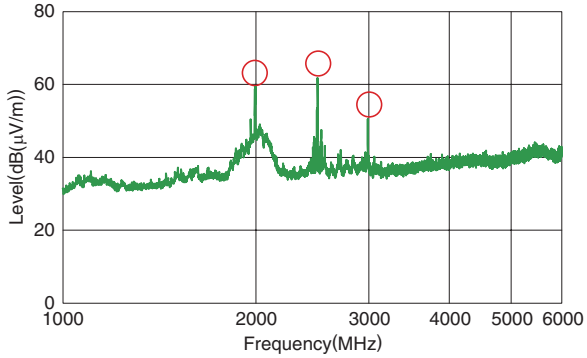
When using a standard common mode filter



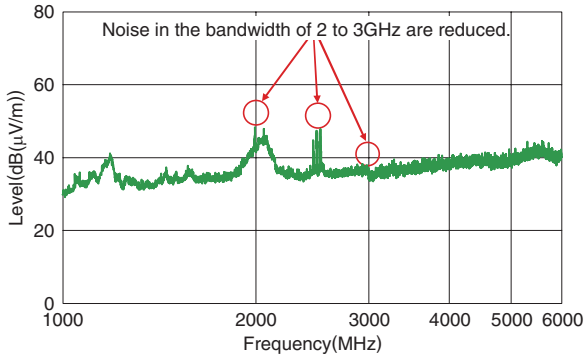
Next, the noise radiation reduction effect exerted by mounting the TCE1210 is shown in Figure 3.

Figure 3 Measurement results of noise radiation

No filter



When using TCE1210-900-2P



The noise level increases in frequency, with a range of 2GHz to 3GHz, when no filter is used, and it especially rises significantly higher than 60dB at 2.5GHz, which is the signal frequency of USB3.0. In this case, we confirmed that noise could be reduced by approximately 15dB when mounting the TCE1210, enabling the attainment of a significant noise reduction effect in the high frequency bandwidth.

3-2. Characteristic impedance

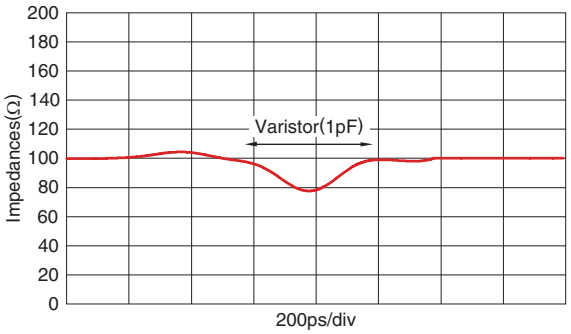
Where we were able to confirm that noise radiation could be reduced without influencing the transmission waveforms as an effect of using a common mode filter in the previous section, we will now confirm the effect of the ESD protection device recently added to the TCE1210 on characteristic impedance. Varistors have been the general option as an ESD measure, and we will now compare the characteristic impedance when using a 1pF varistor with that of when using the TCE1210 (Figure 4).

The characteristic impedance was reduced to less than 80Ω when using a 1pF varistor. As it is specified that the characteristic impedance should be 100±15Ω when using HDMI and 90±7Ω when using USB3.0, it has been confirmed that a 1pF varistor is not suitable for use.

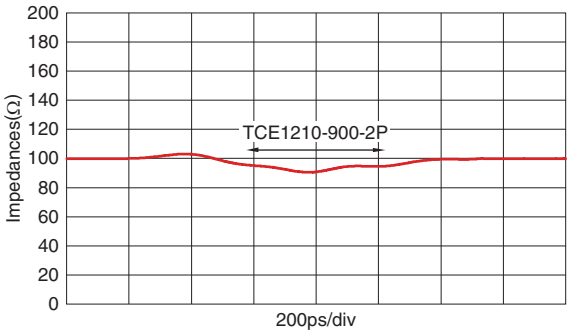
On the other hand, the characteristic impedance was kept at 90Ω or higher when using the TCE1210, confirming that there would be a scarce influence.

Figure 4 Characteristic impedance

When using 1pF varistor



When using TCE1210-900-2P



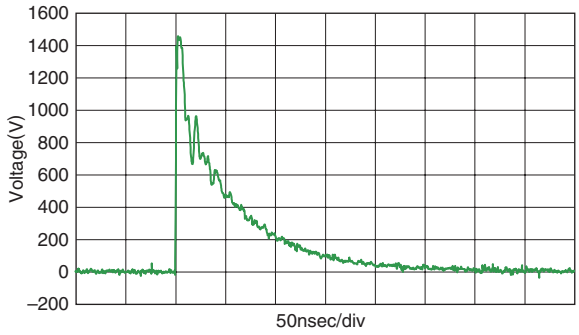
3-3. ESD protection effect

Having confirmed the product's effectiveness for high-speed interfaces such as HDMI and USB3.0 from the viewpoints of transmission waveforms, noise radiation and characteristic impedance when using USB3.0, we next performed a static electricity experiment in order to confirm the protection effect of the newly added ESD protection device on combining the functions. In this experiment, an experimental voltage of +8kV was applied to the TCE1210, under an IEC61000-4-2 compliant environment. The waveform generated when not using the TCE1210 (no filter) and the absorption waveform generated when using the TCE1210 are shown in Figure 5.

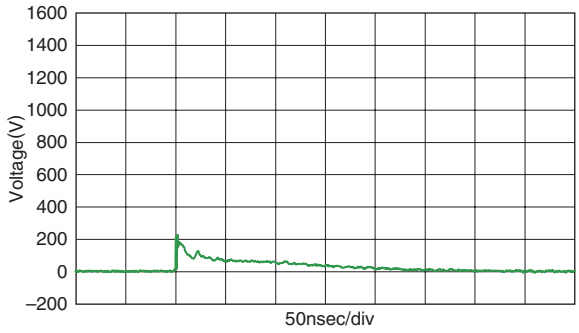
Where more than 1400V of voltage were discharged when not using the TCE1210, static electricity was absorbed and kept as low as approximately 200V through the use of the TCE1210, showing that the product proves to be sufficiently effective in the face of abrupt electrostatic discharges.

Figure 5 Results of static electricity experiments

No filter



When using TCE1210-900-2P



4. Summary

It is expected that reductions in the number of mounted parts and the space they consume will be further enhanced, accompanying the sophistication/downsizing of mobile phones. Also, it is assumed that the necessity for ESD measures will be further increased due to the miniaturization of IC devices accompanying functional sophistication, and that the importance of EMC measures will also increase, since the frequency of transmission signals will become higher.

Due to such backgrounds, it is expected that demands for electronic parts such as common mode filters will become more responsive to high-speed signals, more functionally will be combined and miniaturization will be increased.

TDK-EPC Corporation intends to meet these demands by developing high-performance EMC parts such as the common mode filter and other electronic parts, by effectively utilizing our unique EMC design theory, assessment techniques and technologies for forming conductor patterns for thin-film magnetic heads.

• Please note that the articles from the July 8, 2010 Edition of the Dempa Shimbun contained in this chapter have been edited by our company.