EMI REDUCTION METHOD OF A PCB WITH AN I/O BOARD

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Abstract: An Input/Output (I/O) board is mounted on the main printed circuit board (PCB), in order to connect an interface cable. In this paper, reduction method of radiated emission from equipment that incorporated the PCB with the I/O board was examined using the PCB for experiment (the test PCB). Two methods were investigated for EMI reduction. One method was the shielding connector between main PCB and I/O board, the other was the connecting point of the boards ground (GND). The effect of these two reduction methods was evaluated. From the evaluation result, it was shown that the EMI reduction performance of the shielding connector was more effective than the connecting points of boards GND. Moreover, it was shown that the single-side shielding on connector was sufficiently effective for EMI reduction.
Key words: printed circuit board, EMI, radiated emission, connector, shield,

1. Introduction

An I/O board with an interface cable is prepared apart from the main PCB for diversification of an interface, the miniaturization of equipment and etc. It is known that the equipment that incorporated sub boards, such as the I/O board, will increase radiated emission because the signal speed in a connector becomes high-speed and the number of a signal pin increases [1], [2]. The radiated emission of a stacked-card, which consists of a main PCB and a sub board without interface cable, was examined using common mode current of a signal cable [1], [2]. In these studies, the form of a GND pin in a PCB's connector, and the interval of a signal pin and a GND pin were changed.

In this paper, the reduction method of radiated emission from the equipment that mounted the I/O board is experimentally examined using the test PCB. The PCB consisted of a main PCB, an I/O board with a cable and a connector. The logic circuit is mounted on the main PCB. And, the measurement result of the radiated emission from the PCB is studied. Also, the radiation of the PCB is investigated when the height of a connector and the number of a GND pin are changed.

2.Method of Experiment

2.1 The test PCB for experiment

The composition of a PCB for experiment is shown in Fig. 1. The PCB consists of the main PCB, the I/O board with the cable and the connector that connect these two boards. A cable with a length of 0.2 m is connected to the GND plane of the I/O board. This cable assumes the interface cable with shield. The main PCB has a signal trace and a ground plane. The signal trace is connected to a digital IC at one end and connected with the pins that suppose the connector at the other end. The fundamental composition of the connector consists of one signal pin and one GND pin that is used for the return of a signal. Distance between pins is made into 2.54 mm, corresponding to an actual connector. The sub board has a signal trace and a ground plane. The signal trace is connected to the signal pin at one end and terminated with a resister at the other end. The logic circuit that generates a 20 MHz clock signal is mounted on the main PCB.

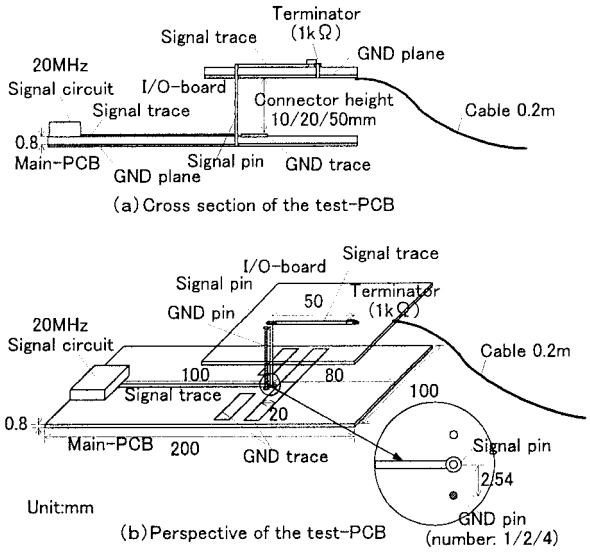


Fig.1. Composition of the test PCB

2.2 Measurement method of radiated emission

The composition of the radiated emission measurement is shown in Fig. 2. The radiated emission was measured in the EMI anechoic chamber according to the EMI 3 m-measurement method. This

measurement method was based on the EMI measurement standard. The test PCB was placed on the table of 0.8 m height and the measurement results express maximum electric field strength in consideration of height pattern and directivity. Electric field of horizontal polarization was studied in this paper.

Moreover, the common mode current on a cable connected to an I/O board was measured, in order to evaluate correspondence with a radiated emission. The common mode current was measured using the current probe.

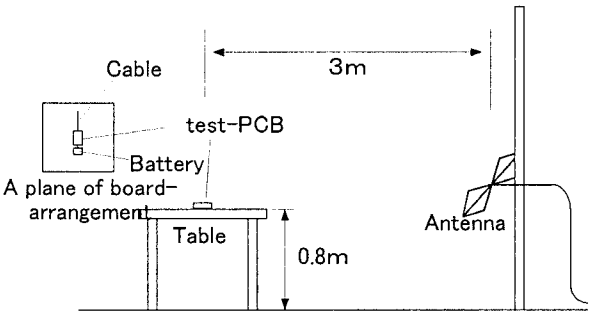


Fig.2. Composition of the radiated emission measurement.

3. Radiated emission from a PCB with an I/O board

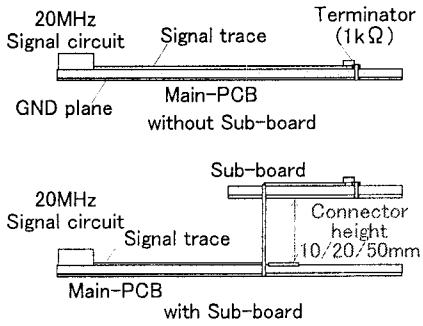
3.1 Effect of a connector on EMI from a PCB

The radiated emission from the test PCB connected a sub board without a cable was measured, in order to evaluate the influence of a sub board only.

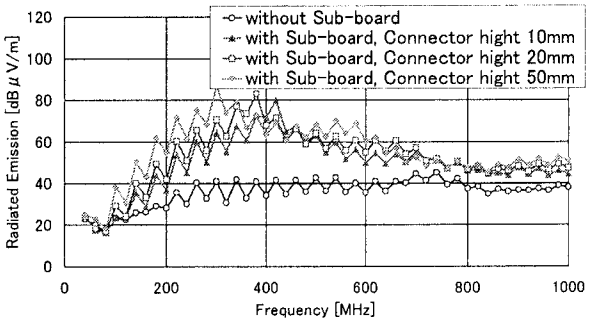
First, influence of a sub board and connector height to radiation was investigated. Composition of the studied PCB is shown in Fig.3 (a). The height of a connector is set to 10, 20 and 50 mm for each PCB. Measurement results of radiated emission from the PCBs are shown in Fig.3 (b). Measurement results of harmonics in the signal (20 MHz clock rate) are indicated in Fig.3 (b). In Fig.3 (b), maximum level of radiated emission from the PCB without sub board is 45 dBμV/m (740 MHz). Maximum level of radiated emission from the PCBs with connector height 10mm, 20mm, 50mm are 80 dBμV/m (420 MHz), 83 dBμV/m (380 MHz), 86 dBμV/m (300 MHz), respectively.

The radiated emission of the PCB with the sub board is about 40 dB higher than that of the PCB without sub board. The radiation from the PCB becomes low as connector height becomes low. But the maximum level of radiated emission from the PCB with connector height of 10 mm is only 6 dB lower than that of a connector height of 50 mm.

Next, influence of the number of GND pin in the connector to radiation was investigated. Composition of the studied GND pin is shown in Fig.4 (a). The number of GND pin is set to 1, 2 and 4.

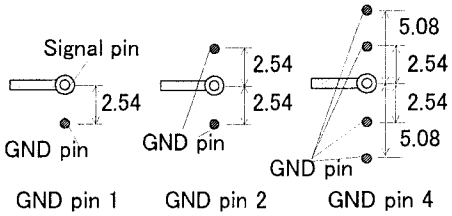


(a) Composition of the PCB

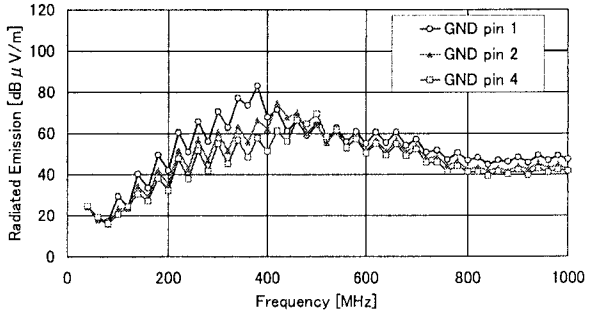


(b) Measurement results of radiation

Fig.3. Influence of sub board and connector height



(a) Composition of the studied GND pin



(b) Measurement results of radiation

Fig.4. Effect of the number of GND pin

Measurement results of radiation from the PCB are shown in Fig.4 (b). In Fig.4 (b), maximum levels of radiated emission from the PCBs with GND pin1, 2, 4 are 83 dBμV/m (380 MHz), 75 dBμV/m (420 MHz), 70 dBμV/m (500 MHz), respectively. The radiation from the PCB becomes low as the number of a GND pin increases. The maximum level of radiated emission from the PCB with four GND pins is 13 dB lower than that with a GND pin.

From these results, a connector with low height and increasing the number of GND pins are effective for reducing the radiated emission from the PCB. But, these reduction effects are not enough to comply with limits requested by EMI standard. For example, the class A limit for radiation specified by CISPR22, the standard of information technology equipment, is 50 dBμV/m at 30 to 230 MHz (3 m method). However, in the case of radiated emission from the PCB with four GND pins, the maximum level of radiated emission is 70 dBμV/m (500 MHz).

Therefore, it is necessary to examine more effective reduction method.

3.2. Influence of an interface cable on EMI from a PCB

Radiated emissions of the I/O board with and without a cable were measured, in order to evaluate the influence of an interface cable for radiation. Measurement results of radiation from the PCB are shown in Fig.5. In Fig.5, the radiated emission from PCB with a cable is 20dB higher than that without a cable. Therefore, an interface cable increases the emission of an I/O board.

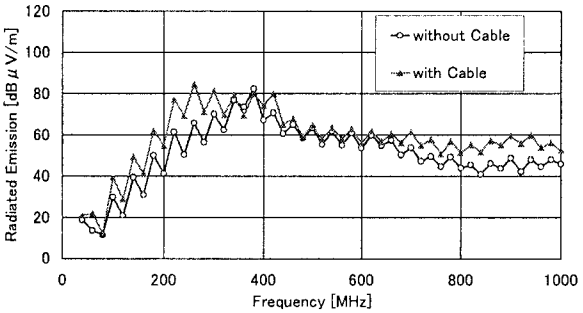


Fig.5 Influence of cable

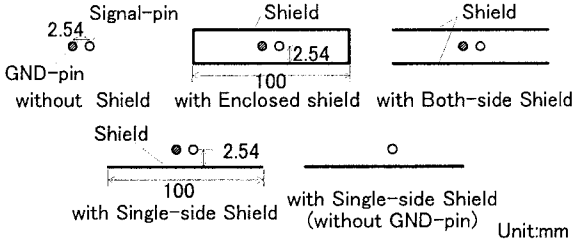
4. EMI reduction method

In this section, two methods of EMI reduction are investigated. One method is the shield of the connector between boards and the other method is the addition of a GND point that connects the boards.

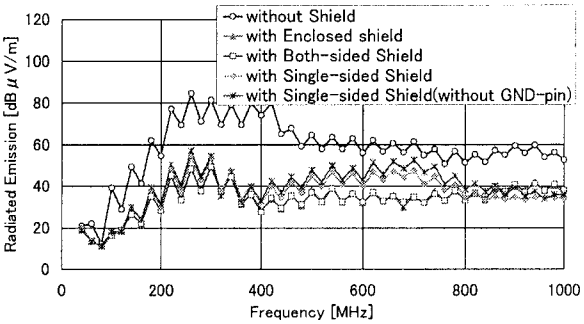
4.1. EMI Reduction effect of a connector shield

Generally, a metal plate that encloses a connector is used for the shield of a connector. In this paper, reduction effect of four types of shield composition shown in Fig. 6 (a) was compared. Measurement results of radiation from the PCB are shown in Fig.6 (b). And, measurement results of common-mode current on a cable connected to the I/O board are shown in Fig.6 (c). In Fig.6 (b), the maximum level of radiated emissions from PCB with enclosed shield on connector is 50 dBμV/m (300 MHz). This radiation level is 35 dB lower than that without shield of connector. The reduction effect of the single-side shield is equivalent to the enclosed shield in the frequency range of 400 MHz or less. If the GND pin for signal returns is removed, 5 dB of emission level will become high, when the single-side shield is applied to the connector.

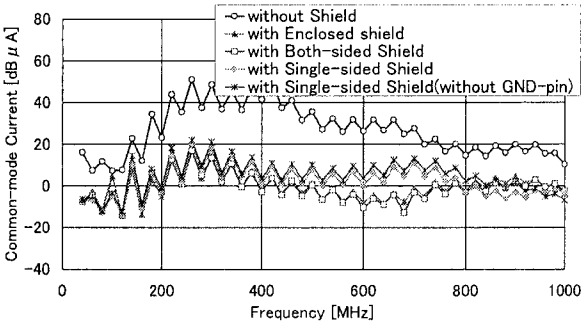
In Figs.6 (b) and (c), the radiated emission varied corresponding to the common mode currents. Therefore, the common mode current on the cable contributed to radiated emission from the PCB.



(a) Composition of the connector shields



(b) Measurement results of radiation



(c) Measurement results of common-mode current

Fig.6 Reduction effect of a connector shield (Connector height: 20 mm)

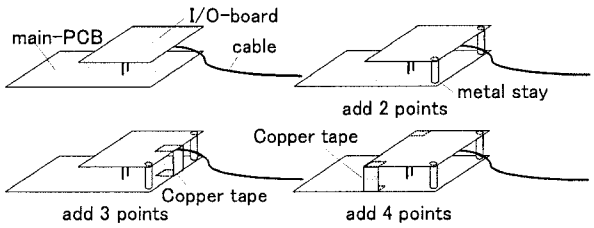
4.2. EMI Reduction effect of GND connection

Next, EMI reduction effect of a GND point that connects the boards was investigated. The composition of the GND connection is shown in Fig. 7 (a). In this paper, the numbers of additional GND points were set to 2, 3 and 4. Measurement results of radiation from the PCB are shown in Fig.7 (b). And, measurement results of common-mode current on a cable connected to the I/O board are shown in Fig.7 (c).

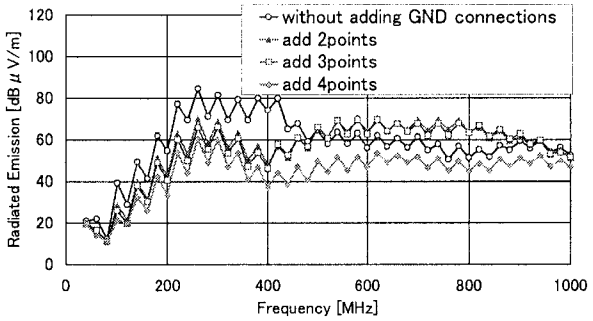
In Fig.7 (b), the radiation from the PCB becomes low as the number of a GND point increases. The maximum level of radiated emission from the PCB with addition 4 points of GND connection is 60

dBμV/m (260 MHz). And, this radiation level is 25 dB lower than that without adding GND connections.

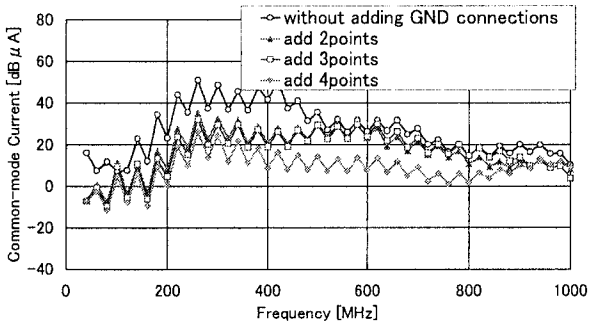
In Figs.7 (b) and (c), the radiated emission varied corresponding to the common mode currents.



(a) Composition of the GND connection



(b) Measurement results of radiation



(c) Measurement results of common-mode current

Fig.7 EMI Reduction effect of GND connection (Connector height: 20 mm)

4.3. Comparison of the EMI reduction methods

The EMI reduction effect of the connector shield, GND connection of boards and combination of these methods was compared. Measurement results of the radiated emission when applying each reduction method are shown in Fig. 8. In Fig.8, the radiated emission from the PCB with the single-side shield on the connector is about 10 dB lower than that with addition 4 points of GND connection. The reduction effect of the single-side shield on the connector is equivalent to combination of two reduction methods.

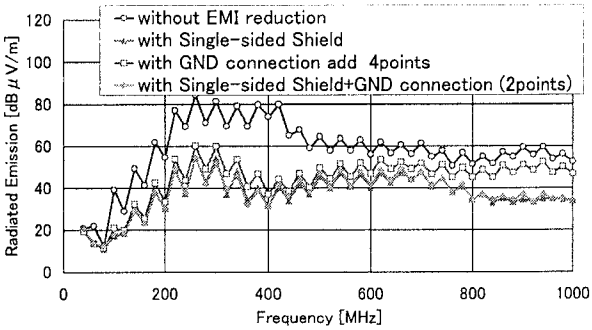


Fig.8 Comparison of the EMI reduction method

5. Conclusion

Reduction method of radiated emission from equipment that incorporated the PCB with the I/O board was experimentally examined using the test PCB. First, influence of a sub board and an interface cable to radiation were investigated. Next, EMI reduction effects of two reduction methods shown below were investigated. One method was the shielding connector between main PCB and I/O board, the other was the connecting point of the boards GND.

The conclusions are as follows.

(1) A PCB with sub board and an interface cable increased radiation EMI.
(2) The shield of the connector between the main PCB and the I/O board reduced radiation EMI. And, the reduction effect of the single-side shield was equivalent to the enclosed shield.
(3) Addition of the connecting point of PCB GND reduced radiation EMI. And, the radiation from the PCB became low as the number of a GND point increased.
(4) The EMI reduction effect of the shielding connector was more effective than the connecting points of PCB GND.
(5) The single-side shield on connector was sufficiently effective for EMI reduction.

Future issue: To theoretical confirm or numerical calculate for the results obtained in this study.

References

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