Verification of suitability of the AAN shown in Fig. G.3 of CISPR 32 for conducted emission measurement on single and two-pair unscreened balanced cables

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***Abstract*—CISPR 32[1] specifies several types of asymmetric artificial network (AAN) for conducted emission measurement on unscreened balanced pair cables. The AAN circuit diagram shown in Figure G.3 of CISPR 32[1] is an example of a transformer-type-AAN, thought to be suitable for measurement on single, two, three and four unscreened balanced pairs even though EUT port of the AAN is a balanced four-pair connector.**

In this paper, we explain how we experimentally verified the suitability of this transformer-type-AAN by measuring common mode termination impedance and voltage division factor (VDF) while changing the balanced pairs to be measured. The results show that deviations among the measured values were sufficiently small and all measured values were met the requirements of CISPR 16-1-2[2]. We concluded that this transformer-type-AAN is suitable for conducted emission measurement on any unscreened balanced pairs.

Keywords—conducted emissions, wired network port, AAN, CISPR 32, CISPR 16

I. Introduction

CISPR 32 is the emission standard for multimedia equipment (MME), which includes information technology equipment, broadcast receivers and so on. According to CISPR 32, conducted emissions at a wired network port intended to connect unscreened balanced multi-pair cables can be measured using an asymmetric artificial network (AAN). Several types of AANs designed for measurement on multi-pair unscreened balanced cables are shown in Figures G.2 through G.7 of CISPR 32[1]. Particularly, the AANs shown in Figures G.2 and G.3 are referred to as transformer-type-AANs because all balanced pairs connected to the EUT port of the AAN are coupled to the line connected to the measurement receiver by using a transformer as shown in Figure 1. A transformer-type-AAN is suited to the situation where some pairs of EUT port of the AAN are known to be unconnected. For example, the AAN shown in Figure G.3 can be used for the measurement on single, two, three and four unscreened balanced pairs, even though the EUT port of the AAN is a balanced four-pair connector.

In this paper, we show that the experimental results verify that the transformer-type-AAN shown in Figure G.3 of CISPR 32[1] is really suitable for measurement on single and two-pair unscreened balanced cables.

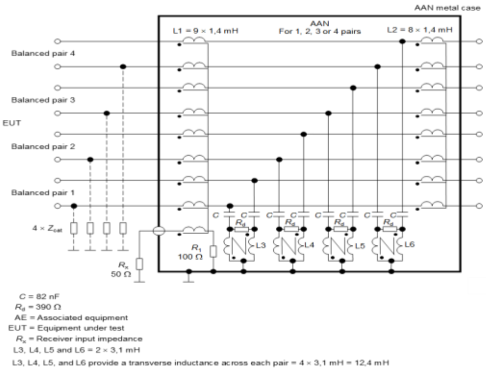


Fig. 1. Example configuration of transformer-type-AAN for four-pair unscreened balanced cable

II. The Parameters of an AAN to Be Measured

According to CISPR 32[1], conducted emission at the wired network port of an EUT including single, two, three and four-pair unscreened balanced cables shall be measured as common mode voltage across a termination impedance of 150 Ω connected to the port under measurement. So, the common mode termination impedance of AANs shall meet the requirement of 150 Ω±20 Ω. The common mode termination impedance means the ratio of common mode voltage to common mode current. Then, common mode current can be estimated from common mode voltage.

When using the AAN, voltage at the EUT port of the AAN is measured by a receiver with an input impedance of 50 Ω. Then, the voltage division factor (VDF) defined as follows must be 9.5±1 dB [1].

$$VDF\ (dB) = 20\log_{10}(V_{CM}/V_m) \qquad (1)$$

Where,

V_{CM} is the common mode voltage appearing across the common mode termination impedance presented to the EUT by the AAN.

V_m is the resulting receiver voltage measured directly at the voltage measurement port of the AAN. V_m is equal to $V_{CM}/3$

Both the common mode termination impedance and VDF shall be measured with all balanced pairs connected to EUT port of the AAN gathered into one in order to assess whether they satisfy the requirements. In the end, suitability of the transformer-type-AAN having a four-pair unscreened balanced EUT port for the conducted emission measurement on single and two-pair cables can be verified by assessing common mode termination impedance and VDF. The AAN met the requirements of CISPR 16-1-2[2] for all single and two-pair balanced pairs under measurement. The measurements were carried out in accordance with CISPR 16-1-2[2]. Transformer-type-AANs with a four-pair unscreened balanced EUT port are the type most commonly used for conducted emission measurements.

Fig. 2 shows the designation of electrodes of the connector for the four-pair unscreened balanced cable. Numbers show electrodes. Table I shows combinations of the connector electrodes to be measured.

Fig. 2. Designation of connector for four-pair unscreened balanced cable

TABLE I. COMBINATION OF ELECTRODES FOR UNSCREENED BALANCED PAIRS TO BE MEASURED

Category of cable	Combination of electrodes to be measured	Remarks
Cat. 3	L1-L2	
	L3-L6	
	L4-L5	Normally used
	L7-L8	
	All electrodes	
Cat. 5	L1-L2-L3-L6	Normally used
	L4-L5-L7-L8	
	All electrodes	

III. THE TERMINATION IMPEDANCE

Fig. 3 shows the arrangement for termination impedance measurement. This is in accordance with CISPR 16-1-2[2]. The combinations of electrodes a and b are as shown in Table I.

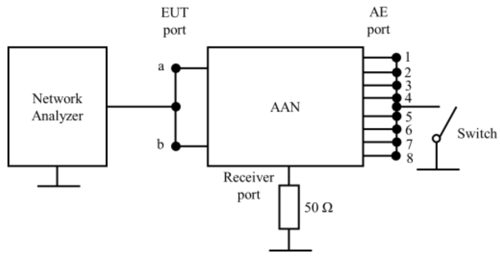
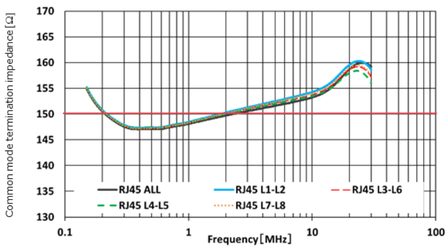
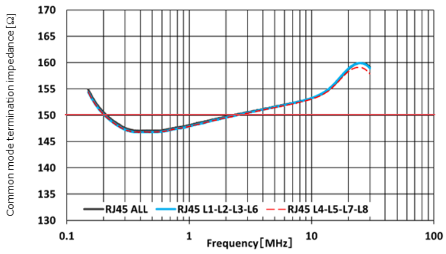


Fig. 3. Arrangement for the termination impedance measurement

The measurement results are shown in Fig. 4 and Fig. 5. Using a Cat.3 Longitudinal Conversion Loss (LCL) adaptor, the maximum deviation of termination impedances of different combination of electrodes was 5 Ω at 30 MHz. Using a Cat.5 LCL adaptor, the maximum deviation was 2 Ω at 30 MHz. All measured values were within 150 Ω ± 20 Ω across a frequency range of 150 kHz to 30 MHz. That means the measured values comply with the requirements of CISPR 32[1].

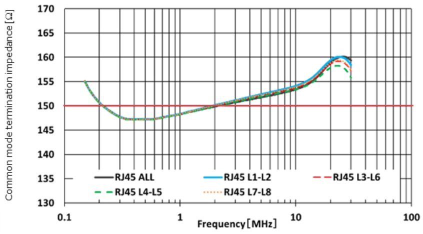


(a) LCL adaptor for Cat.3

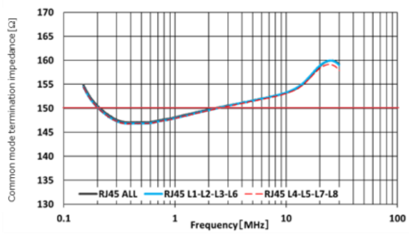


(b) LCL adaptor for Cat.5

Fig. 4. Measured termination impedances with Associated Equipment (AE) port open



(a) LCL adaptor for Cat.3



(b) LCL adaptor for Cat.5

Fig. 5. Measured termination impedances with AE port short

IV. Voltage Division Factor (VDF)

Fig. 6 shows the arrangement for voltage division factor measurement based on CISPR 16-1-2[2].

Fig. 7 shows the measurement results. Using a Cat.3 LCL adaptor, the maximum deviation of VDF of different combinations of electrodes was 0.1 dB. Using a Cat.5 LCL adaptor, the maximum deviation was also 0.1 dB. All measured VDFs were within 9.5 dB ± 1 dB across a frequency range of 150 kHz to 30 Hz. That means the measured VDF values comply with the requirements of CISPR 16-1-2[2].

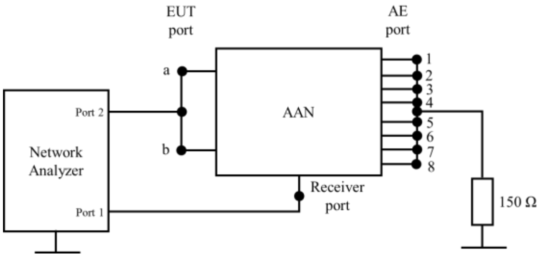
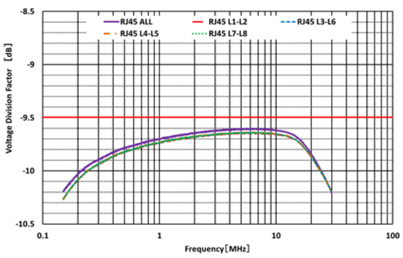
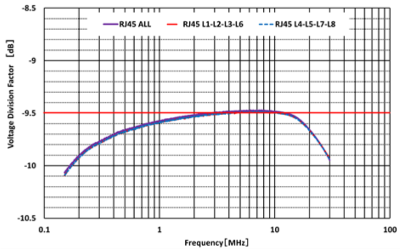


Fig. 6. Arrangement for voltage division factor measurement



(a) LCL adaptor for Cat.3

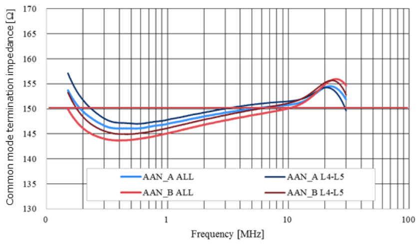


(b) LCL adaptor for Cat.5

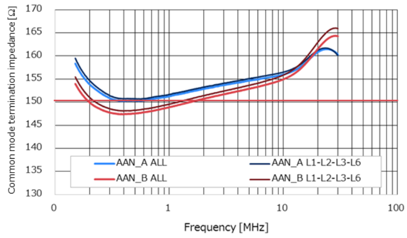
Fig. 7. Measured voltage division factors (VDF)

V. Difference among Products

To evaluate the difference among products, termination impedance and VDF of two transformer-type-AANs with different product serial numbers in the same model were measured. The two AANs are called AAN_A and AAN_B. Fig. 8 and Fig. 9 show the measured termination impedances. Using a Cat.3 LCL adaptor, the maximum deviation between two AANs was 3.9 dB at 150 kHz. Using a Cat.5 LCL adaptor, the maximum deviation was 4.4 dB at 150 kHz. The measured values comply with the requirements of CISPR 16-1-2[2]

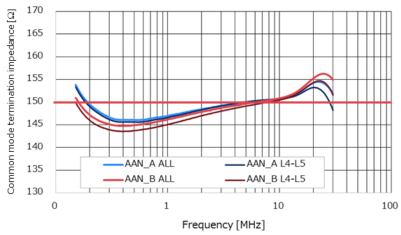


(a) LCL adaptor for Cat.3

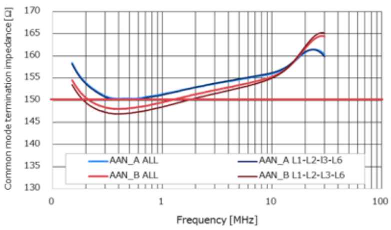


(b) LCL adaptor for Cat.5

Fig. 8. Measured termination impedances of two AANs with AE port open



(a) LCL adaptor for Cat.3



(b) LCL adaptor for Cat.5

Fig. 9. Measured termination impedance of two AANs with AE port short

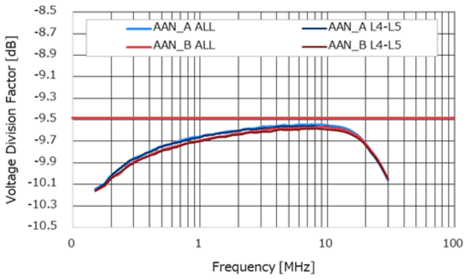
Fig.10 shows the measured VDF of the two AANs. Using a Cat.3 LCL adaptor, maximum deviation of the two AANs was 0.14 dB. Using a Cat.5 LCL adaptor, the maximum deviation was 0.18 dB. The measured VDF values of the two AANs with different product serial numbers comply with the requirements of CISPR 16-1-2[2].

VI. Effect on Uncertainty

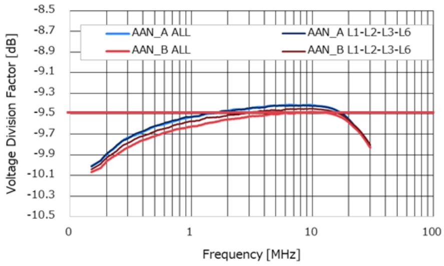
For taking into account uncertainty based on CISPR 16-4-2[3], input quantities to be considered for conducted emission measurements on unscreened balanced pair cables using an AAN are receiver reading, attenuation of the connection between AAN and receiver, AAN VDF, AAN VDF frequency interpolation, receiver corrections, mismatch effects between AAN receiver port and receiver, common mode termination impedance of the AAN, LCL of the AAN, effect of disturbances from the AE, and effect of environment. Among these input quantities, the number of pairs of unscreened balanced cable connected to EUT port of the AAN affects AAN VDF, AAN VDF frequency interpolation, common mode termination impedance of the AAN, and LCL of the AAN. All measured values of VDF and common mode termination impedance met the requirements of CISPR 16-1-2[2]. Then, the effects on input quantities, that were AAN VDF, AAN VDF frequency interpolation, common mode termination impedance of the AAN, and LCL of the AAN, were sufficiently small. Therefore, the effects on uncertainty by the number of pairs connected to EUT port of the transformer-type-AAN shown in Figure G.3 of CISPR 32[1] were sufficiently small.

VII. Conclusion

Suitability of a transformer-type-AAN having a four-pair unscreened balanced EUT port, of which an example circuit diagram is shown in Figure G.3 of CISPR 32[1], for conducted emission measurement on single and two-pair cables was verified.



(a) LCL adaptor for Cat.3



(b) LCL adaptor for Cat.5

Fig. 10. Measured voltage division factor (VDF) of two AANs

To verify the suitability, common mode termination impedance and voltage division factor (VDF), which are related to accuracy of measurement results, were measured for single and two-pair balanced pairs. The measured values were assessed to determine whether they met the requirements of CISPR 16-1-2[2].

The maximum deviation among measured termination impedances and VDFs were 2 or 5 Ω and 0.1 dB, respectively. All measured values met the requirements of CISPR 16-1-2[2].

Moreover, basically the same results were obtained by the measurement of two transformer-type-AANs with different serial numbers.

In summary, we found that a transformer-type-AAN having a four-pair unscreened balanced EUT port is suitable for conducted emission measurement on single and two-pair unscreened balanced pair cables.

References

[1] CISPR 32, Electromagnetic compatibility of multimedia equipment – Emission requirements, Edition 2.0, March 2015.

[2] CISPR 16-1-2, Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immyunity measuring apparatys – Coupling devices for conducted disturbance measurements, Edition 2.1, Nov. 2017.

[3] CISPR 16-4-2, Specification for radio disturbance and immunity measureing apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty