PAPER *Special Issue on Electromagnetic Compatibility*

Estimation of Electromagnetic Interference Field Emitted from Telecommunications Line

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SUMMARY An electric field is created around a telecommunications line by common-mode currents caused by clock signals, switching pulses and digitally transmitted signals. This field is a potential source of interference to radio reception. This paper describes measurement results for interference fields radiated from a telecommunications line. A method using optical fiber was used to measure the relation between common mode voltage and radiated electric field, and the results were compared with the calculated results discussed in IEC/CISPR. Our results show that the limits discussed in the CISPR are effective in restricting the electromagnetic interference due to conducted disturbances at telecommunication ports. The electric field strength from the telecommunications line caused by telecommunications signals is estimated on the basis of the relation between the common mode voltage and the radiated field strength. In this estimation, the dependence on the longitudinal conversion loss (LCL) of the telecommunications line is taken into account. The results show that the telecommunications signal on the ISDN basic access interface is not an interference source provided that the LCL of the telecommunications system meets the requirements for the ISDN interface.

key words: *interference, disturbance, EMC, EMI, common mode, unbalance*

1. Introduction

The wide-spread introduction of digital, high-speed, and broad-band equipment in advanced information systems has resulted in a serious increase in electromagnetic noise and resulting interference among systems.

As a result, a global interest has also arisen in the problems of electromagnetic compatibility (EMC) for telecommunications systems. Two sources of interference have been studied. One is the digital pulses of the clock oscillator and switching regulator. The harmonics of the digital pulses, which can be unintentionally coupled via AC mains cables, telecommunications cables or by direct radiation, can be a significant source of interference [1]. The other is the signal's common-mode component caused by both equipment unbalance and telecommunications line unbalance. It has been reported that this component can also constitute a potential source of electromagnetic interference [2]-[6]. Methods of estimating the signal's common mode component have already been studied [4], [5].

Manuscript received June 23, 1994.
Manuscript revised September 19, 1994.

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To restrict electromagnetic noise and to achieve EMC, the International Special Committee on Radio Interference (CISPR) and ITU Telecommunication Standardization Sector (ITU-T, former CCITT) have been investigating the requirements for disturbance at telecommunications ports. CISPR has been investigating the limits and measurement methods of disturbances at telecommunication ports [7]. ITU-T has been estimating the noise field caused by digitally transmitted signals, and investigating the limits and measurement method of disturbances from the ISDN basic access interface. CISPR has proposed disturbance limits at telecommunication ports on the basis of the protection for radio reception and the theoretical conversion factor between the common mode voltage and the field strength [8]-[10]. However, the relationship between the common mode voltage and the field strength has not been determined, and the contribution of the digital signal of the ISDN basic interface to radio reception has not been investigated.

Electromagnetic field radiated from a telecommunications line is originated by both common mode current and differential mode current of the line. In the case of the aerial telecommunications line, the distance between conductors of twisted pair is far smaller than the distance between the telecommunications line and the ground. Therefore, the radiated field due to differential mode current is negligible. In this paper, common mode current is taken into account to estimate the electromagnetic interference field from a telecommunications line.

This paper discribes the relationship between the interference field and the common mode voltage at telecommunication ports. This relationship was measured by using optical technology. The relationship and the conversion from the signal's differential mode voltage to common mode voltage was then estimated using actual equipment. The suitability of the disturbance limits at telecommunication ports is discussed on the basis of the estimation results.

2. Disturbance Limits Proposed

CISPR Sub-Committee G (SCG) has proposed a limit on electric field strength of 35 dBμV/m for the average value [8]. Class A and Class B equipment is required to meet this limit at distances of 30 m and 10 m

Table 1 Limits of common-mode disturbances at signal ports in the frequency range 0.15 to 30 MHz (Average value).

	Frequency (MHz)	Voltage limits (dBuV)	Current limits (dBuA)
Class A equipment	0.15 - 0.5	84 - 74	40 - 30
	0.5 - 30	74	30
Class B equipment	0.15 - 0.5	74 - 64	30 - 20
	0.5 - 30	64	20

Note: The limits decrease linearly with the logarithm of the frequency in the range 0.15 to 0.5 MHz. The voltage and current limits are derived for use with an Impedance Stabilization Network (ISN) which presents a common mode impedance of 150 ohms to the signal port under test (20log150=44 dB)

respectively from telecommunications lines. This limit is calculated from the radio-frequency protection ratios for LF and MF broadcasting recommended by ITU-R (former CCIR), attenuation of wanted broadcast signals by a building, attenuation of interference fields by walls, and an allowance for probability. The limit of 35 dBμV/m was proposed by I. P. Macfarlane (Telecom Australia) at the 1988 CISPR meeting on the basis of following equation [8].

$$L = F_S - P_R - B + W + P \quad (1)$$

where

L: limit of field strength (dBμV/m)

F_S: field strength of wanted signal (60 to 80 dBμV/m)

P_R: protection ratio (55 dB)

B: attenuation of wanted field by building (0 to 20 dB)

W: attenuation of interference field by wall (0 to 20 dB)

P: allowance for probability (20 dB)

Limits on common mode disturbances at telecommunication ports are obtained from the magnetic field around a straight cable in free space, calculated using the Biot-Savart law [9]. The proposed average limits on common mode disturbances for Class A and Class B equipment are snown in Table 1 [10].

Here we define the factor F_{AV} which stands for the conversion factor between the field strength and the common mode voltage as follow.

$$F_{AV}(\text{dB}) = V_L(\text{dB}\mu\text{V}) - L(\text{dB}\mu\text{V/m}) - 20\log(R/10) \quad (2)$$

where V_L is the voltage limits in Table 1, L is the limit of field strength (35 dBμV/m) and R is the distance from the telecommunications cable. R is chosen to be 10 m and 30 m for the Class B and Class A limits, respectively. By substituting the limits shown in Table 1 into Eq. (2), F_{AV} of 39 to 29 dB decreasing linearly

Table 2 Conversion factor from electric field to common mode voltage and current.

Frequency (MHz)	F_{AV} (dB)	F_{AI} (dB)
0.15 – 0.5	39 – 29	-5 – -15
0.5 – 30	29	-15

with the logarithm of the frequency in the range 0.15 to 0.5 MHz and 29 dB in the range 0.5 to 30 MHz are obtained. The limits shown in Table 1 is proposed on the basis of the difference of the protection distance between Class A and Class B equipment, that is, $20\log[30(\text{m})/10(\text{m})] \fallingdotseq 10$ (dB). Therefore, the values of F_{AV} are independent of the class of the limits and are shown in Table 2. We then define the factor F_{AI} which stands for the conversion factor between the field strength and the common mode current. F_{AI} is given by Eq. (3) on the basis of the conversion factor between the voltage limits and the current limits as shown in the note of Table 1.

$$F_{AI}(\text{dB}) = F_{AV}(\text{dB}) - 44(\text{dB}) \quad (3)$$

F_{AI} is also independent of the class of the limits and the values of F_{AI} are also shown in Table 2. F_{AV} and F_{AI} are originally independent on the frequency of the disturbance. However, the actual conversion factor between the radiated field from the telecommunications line and the common mode disturbance at telecommunication ports may depend on the frequency of the disturbance. Therefore, it is necessary to confirm by experiments wheather the interference field strength also meets the CISPR limits provided that the telecommunications equipment meets the limits of common mode disturbances at the telecommunication ports. In this paper, the relationship between the radiated field and the common mode disturbance at telecommunication ports was measured by using an experimental telecommunications line and the results were compared with the values shown in Table 2.

3. Interference Field Strength Radiated from Cable

3.1 Measurement Configurations

The interference field radiated from a telecommunications line was measured using the experimental setup shown in Fig. 1. 1-km-long straight overhead cables were suspended alongside a road. A hut was constructed at each end of the cable. Two types of balanced pair cables were used, of the type commonly used for subscriber loops. One type had metallic sheath and the other did not. There were 50 pairs in each cable. The cable without metallic sheath is mostly used for a telecommunications line. In this case the shielding effect cannot be expected. Therefore, we used the cable

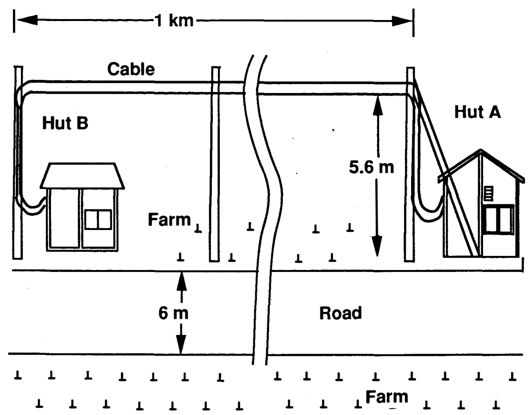


Fig. 1 Configuration of overhead cable employed in the experiment.

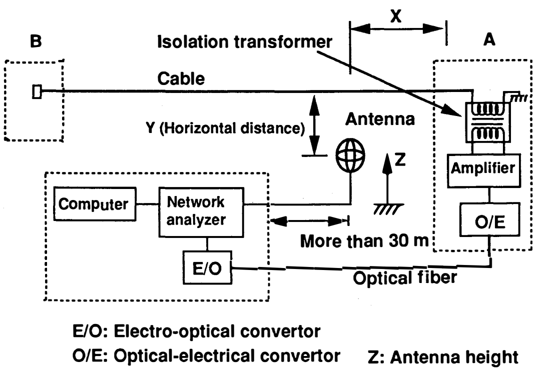


Fig. 2 Experimental layout for measuring the conversion factor from electric field to common mode voltage.

without metallic sheath in the following experiment to do a severe estimation on the interference field.

The experimental layout is shown in Fig. 2. An optical-electrical (O/E) converter with an amplifier was connected at one end of the cable (End A in Fig. 2), and a signal was applied to one pair in the cable through a transformer. At the other end, the wires of the pair were terminated to ground through a common mode impedance of 150 ohms. An omnidirectional loop antenna [11] was used to measure the electric field strength radiated from the telecommunication line. A network analyser was connected to the antenna, and the output signal port of the analyser was connected to the transformer at end A by means of an optical fiber cable. The optical fiber cable was used to prevent interaction between the field measurement equipment and the signal injection equipment.

In this experiment, the transformer plays the role of telecommunications equipment. Here, we define F_{AVm} which stands for the conversion factor between the output voltage of the transformer V_{OUT} and the field strength E as follow.

$$F_{AVm}(\mathrm{dB}) = V_{OUT}(\mathrm{dB}\mu\mathrm{V}) - 20\log E\,(\mathrm{dB}\mu\mathrm{V/m}) \quad (4)$$

Table 3 Parameters for the experiment.

Term	Parameter
Antenna position (X direction dependence)	X: 0 - 270(m) 10 m step (x < 100 m) 20 m step (x > 100 m) Y: 2 m Z: 1.58m
Antenna position (Y direction dependence)	X: 260 m Y: 0 - 20 m 5 m step Z: 1.58m
Frequency range	0.1 - 30 (MHz)

$$E = (E_X^2 + E_Y^2 + E_Z^2)^{1/2} \quad (5)$$

where E_X, E_Y and E_Z are X, Y and Z component of E, respectively. F_{AVmX} which stands for the X component of F_{AVm} is given by

$$F_{AVmX}(\mathrm{dB}) = ATT_2(\mathrm{dB}) - ATT_{1X}(\mathrm{dB}) - \{AF_X + C_{LOSS}\}, \quad (6)$$

where

$$ATT_{1X}(\mathrm{dB}) = 20\log(S_{OUT}/V_{INX}) \quad (7)$$

$$ATT_2(\mathrm{dB}) = 20\log(S_{OUT}/V_{OUT}). \quad (8)$$

In Eqs. (6), (7) and (8), S_{OUT} is the output level of the analyser, V_{INX} is the output of the X component of the antenna, and V_{OUT} is the output of the transformer when the port is terminated by 150 ohms, where 150 ohms is the common mode impedance of the telecommunication ports discussed in CISPR [10]. AF_X is the antenna factor of the X component of the antenna, and C_{LOSS} is the loss of the cable connected between the antenna and the analyser. The factors F_{AVmY} and F_{AVmZ} for the Y and Z component are represented similarly.

The factor F_{AVm} can be calculated from F_{AVmX}, F_{AVmY} and F_{AVmZ}, and it is given by

$$F_{AVm} = -20\log\{(1/CF_{mX})^2 + (1/CF_{mY})^2 + (1/CF_{mZ})^2\}^{1/2} \quad (9)$$

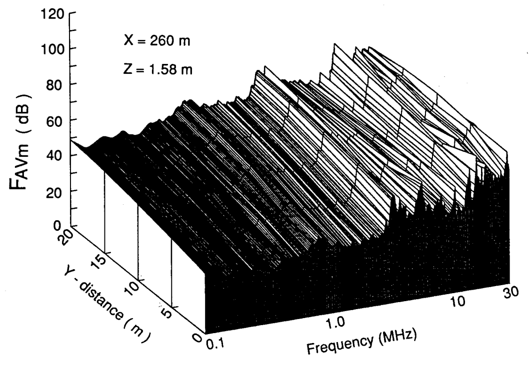
where

$$CF_{mX} = 10^{(F_{AVmX}/20)},\ CF_{mY} = 10^{(F_{AVmY}/20)},\ CF_{mZ} = 10^{(F_{AVmZ}/20)} \quad (10)$$

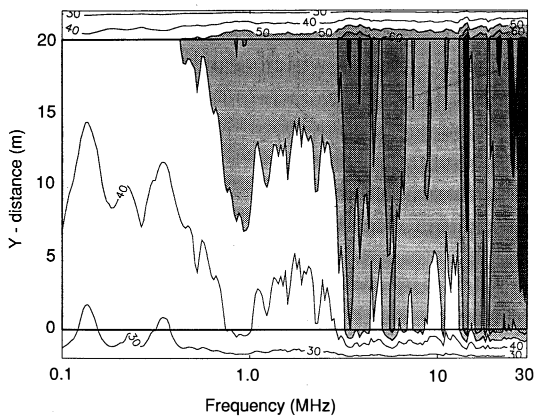
3.2 Measurement Results

The parameters of the experiment for measuring the dependence on distance from the cable of the conversion factor F_{AVm} are summarized in Table 3. In Table 3, X, Y and Z show horizontal distance from Hut A, horizontal distance from the cable, and the distance between the cable and the ground, respectively.

In the experiment, the measurement procedure is as follows. First, F_{AVm} was measured in the range of X



(a) Three dimensional display



(b) Two dimensional display

Fig. 3 Dependence of Y-distance on conversion factor.

$=0$ m to 270 m to obtain the propagation characteristics of interference field on the longitudinal direction of the cable. In this measurement, horizontal distance from the cable Y was fixed on 2 m. Next, F_{AVm} was measured at intervals of 5 m over the horizontal distance from 0 m to 20 m to obtain the dependence of the distance from the cable on the interference field from the cable. In this measurement, X is fixed on 260 m. The value of $X=260$ m is chosen in order to eliminate the affection caused by the cable end. In these experiments, a network analyser was used as shown in Fig. 2, and the number of samples on frequency domain of the analyser was 401 points in the frequency range of 100 kHz to 30 MHz.

Figure 3 shows the distance dependence in the X direction from the disturbance source (End A in Fig. 2). Figure 3 shows that F_{AVm} increases with the increase of the frequency. This is due to decrease of high frequency components of disturbances because the measuring point ($X=260$ m) is far away from the signal injection point. Figure 3 also shows that F_{AVm} increases regardless of the frequency with the increase of the distance from the cable (Y-distance). This means that the radiated field strength from the cable

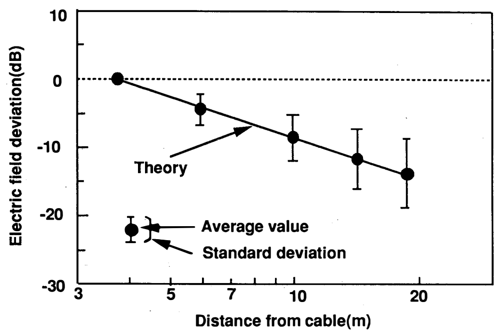


Fig. 4 Dependence of electric field strength on distance from cable.

decreases with the increase of Y-distance. The dependence of the field strength on the distance from the cable was obtained by the measurment result shown in Fig. 3. Figure 4 shows the result. In Fig. 4, normalized field strength is indicated on the basis of the Eq. (11).

$$E(r, f_i)=E(r, f_i)-E(r_0, f_i)$$
$$=F_{AVm}(r_0, f_i)-F_{AVm}(r, f_i) \quad (11)$$

$$r=\{Y^2-(h-Z)^2\}^{1/2} \quad (12)$$

$$r_0=h-Z=3.42\,(\mathrm{m}) \quad (13)$$

where r is the distance from the cable, h is the distance between the cable and the ground and f_i is the measurement frequency. The number of f_i is 401 in the experiment. In Fig. 4, ● shows the average deviation of the field strength represented by Eq. (14).

$$\Delta E_{AVG}(r)=\frac{1}{N}\sum_{i=1}^{N}\Delta E(r, f_i) \quad (14)$$

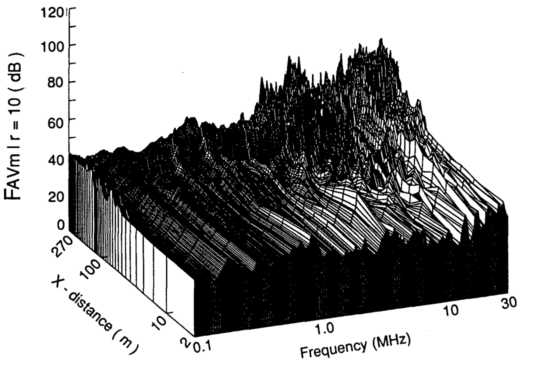
In Eq. (14), $N=401$ and the straight line shows the distance dependence calculated on the assumption that the field strength is inversely propotional to the distance as shown in Eq. (15).

$$\Delta E(r, f_i)=20\log(1/r) \quad (15)$$

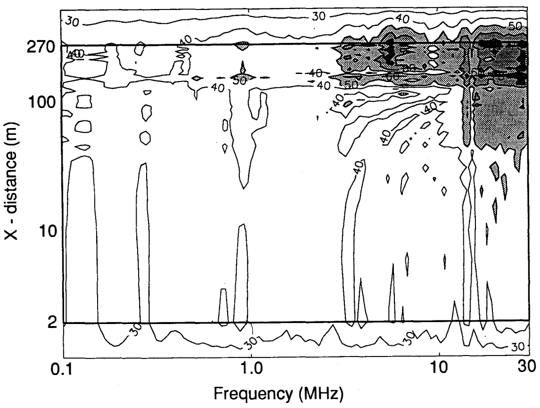
Figure 4 shows that average values are inversely propotional to the distance nevertheless those have some deviations. This means that the field strength radiated from the cable is inversely propotional to the distance. Then F_{AVm} at a distance of 10 m, $F_{AVm}|_{r=10}$, is given by

$$F_{AVm}|_{r=10}=F_{AVm}(r)-20\log(r/10) \quad (16)$$

Figure 5 shows $F_{AVm}|_{r=10}$ obtained by the F_{AVm} measured in the condition of $X=0$ m to 260 m, $Y=2$ m and $Z=1.58$ m. Figure 5 shows that $F_{AVm}|_{r=10}$ increases gradually as the distance from the injection point (Hut A) increases in the frequency range of 100 kHz to 3 MHz. This means that the field strength radiated from the cable decreases with the distance from the injection point. In the frequency range of 100 kHz to 3 MHz, $F_{AVm}|_{r=10}$ is 35 dB$\pm$5 dB and almost



(a) Three dimensional display



(b) Two dimensional display

Fig. 5 Dependence of X-distance on conversion factor.

agrees with F_{AV} shown in Table 2. In the frequency range above 3 MHz, $F_{AVm}|_{r=10}$ increases rapidly with the increase of the X-distance. This means that the common mode disturbances in the frequency range above 3 MHz decrease with the increase of the distance from the signal injection point.

F_{AVm} stands for the conversion factor between the field strength at a distance 10 m from the cable and the common mode voltage as shown in Eq. (2). If the factor $F_{AVm}|_{r=10}$ is equal to or greater than F_{AV}, that is, if the telecommunications equipment observes the common mode disturbance limits at telecommunication ports, it is reasonable that the equipment meets the interference field limits (CISPR limits) as well.

Figure 5 shows that $F_{AVm}|_{r=10}$ is equal to or greater than F_{AV}. On the basis of the discussion above mentioned, it is confirmed that if the telecommunications equipment observes the common mode disturbance limits at telecommunication ports, the equipment meets the interference field limits (CISPR limits) as well.

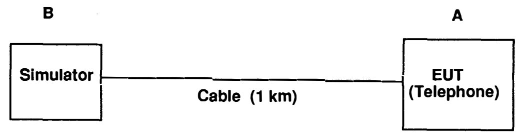


Fig. 6 Experimental setup for measuring the electric field from telecommunications line.

4. Interference Field Strength Radiated From Telecommunications Line

4.1 Measurement of Field Strength from Actual Equipment

The interference field strength radiated from a telecommunications line and the common mode voltages at telecommunication ports were measured to check the disturbance limits shown in Table 1 by using actual equipment. The experimental setup is shown in Fig. 6. The telecommunications line shown in Fig. 1 was employed and a key-telephone system was remotely operated via a 1-km length of two-wire overhead cable. The radiated electric field was measured by a loop antenna which was positioned under the cable. Then the field strength at a distance of 30 m from the cable was estimated.

4.2 Suitability of the Disturbance Limits

To check the suitability of the proposed limits, the radiated electric field strength on which the equipment under test (EUT) is assumed to have common-mode voltages corresponding with the proposed limits was estimated.

The estimation was carried out using the measured electric fields radiated from the telecommunications line shown in Fig. 1 on the basis of the following process.

1) Common-mode voltages V_C at telecommunications signal ports were measured by an Impedance Stabilization Network (ISN)[10] and several typical frequencies were selected.

2) The difference between the selected voltages and the limits in Table 1, F_A(dB), was calculated with Eq. (17).

$$F_A(\mathrm{dB}) = V_L(\mathrm{dB}\mu\mathrm{V}) - V_c(\mathrm{dB}\mu\mathrm{V}) \tag{17}$$

3) The measured magnetic field strength was converted into electric field E_L (dBμV/m) using the intrinsic impedance of free space (377 ohms).

4) The estimated electric field E_E(dBμV/m) was obtained by Eq. (18).

$$E_E(\mathrm{dB}\mu\mathrm{V/m}) = E_L(\mathrm{dB}\mu\mathrm{V/m}) + F_A(\mathrm{dB}) + 20\log(R/10) \tag{18}$$

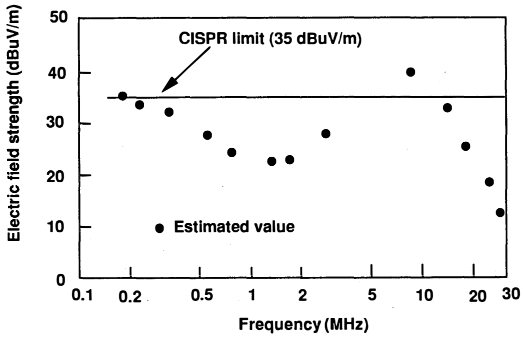


Fig. 7 Estimated interference field strength from telecommunications line.

Figure 7 shows the estimated electric field strengths at a distance of 30 m from the telecommunications line shown in Fig. 1. The plotted values shown in Fig. 7 are the estimated field strengths at which each frequency has a common mode voltage corresponding to the proposed limits.

Figure 7 shows that the estimated field strengths are approximately equivalent to the disturbance limits at telecommunications signal ports proposed by CISPR/SCG [8]. The results show that the interference field strength radiated from telecommunications line almost meets the CISPR limits provided that the telecommunications equipment meets the limits of conducted common mode disturbances at telecommunication ports.

5. Interference Field Caused by the Common Mode Voltage of a Signal

Converting a signal's differential mode voltages into common mode voltages can constitute a potential source of electromagnetic interference to radio receivers [3]. The radiated interference field strength caused by the common mode voltage of a signal was measured and the contribution to radio interference was estimated.

5. 1 Measurement of Interference Field Due to Line Unbalance

An experiment was carried out to estimate the interference field caused by telecommunications line unbalance. Figure 8 shows the experimental layout for measuring field strength radiated from the telecommunications line. A signal was supplied at one end of the overhead cable through a transformer, and the radiated magnetic field was measured by a loop antenna positioned under the cable. The transformer simulated the signal transmission output of the telecommunications equipment. The line unbalance was controlled by the resistance R_X. The line unbalance and the equipment unbalance are usually represented by longitudinal conversion loss (LCL), where LCL represents the unbalance about earth as defined by CCITT [12].

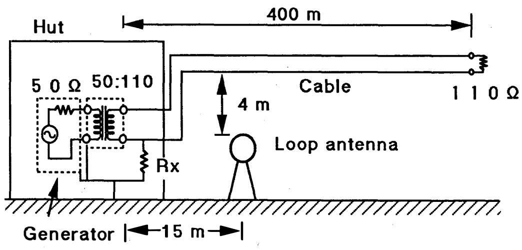


Fig. 8 Experimental layout for measuring the field strength radiated from telecommunications line.

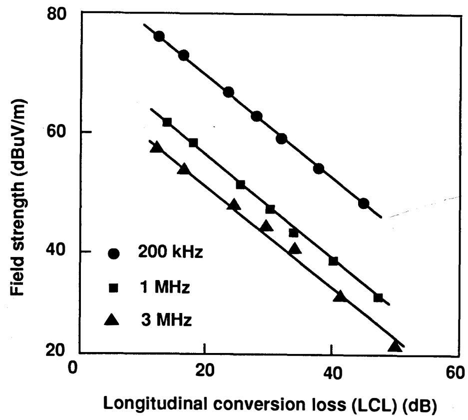


Fig. 9 Relationship between LCL of the telecommunications line and the radiated field strength.

The relationship between LCL and the radiated electric field strength was measured for 200 kHz, 1 MHz and 3 MHz. The results are shown in Fig. 9. The field strength radiated from telecommunications line is inversely propotional to the LCL of the line. This shows that line unbalance may cause electromagnetic interference.

5. 2 Common Mode Voltage of Signal

Common mode voltage converted from a signal's differential mode voltage can be approximated by the following equation [4].

$$V_C = V_D - LCL + 20\log_{10}(1 + 2Z_1/Z_0) \tag{19}$$

where V_C is the common mode voltage, V_D is the differential mode voltage, Z_1 is the common mode impedance of the telecommunications line, and Z_0 is the differential mode impedance of the telecommunications line.

From Eq. (2), the electric field strength L is given by

$$L\,(\mathrm{dB}\mu\mathrm{V/m}) = V_C - F_{AV} - 20\log(R/10) \tag{20}$$

where, either the theoretical value of F_{AV} shown in Table 2 or the measured value of shown in Fig. 3 can be used. In this estimation, the values in Table 2 were used as typical values.

The interference field strength caused by converting differential mode voltages to common mode voltages were measured using an actual communications mode at the ISDN basic access interface bus line. The experimental setup is illustrated in Fig. 10. The telecommunication line shown in Fig. 1 was used for the measurement. An ISDN digital telephone was connected at A and an ISDN network simulator was connected at B. In Fig. 10, a capacitor and a resistor were used to reduce the LCL of the line. Because ambient noise made it difficult to measure the interference field, the LCL of the line was reduced to 7 dB to increase the common mode voltage thus allowing easy measurement of the field.

Figure 11 shows the measured and estimated interference field strength caused by digitally transmitted signals. Three frequencies of the differential mode signal were selected, and the differential mode signal level and the electric field strength were measured. In Fig. 11, solid lines show calculated values for LCL of 7 dB, 40 dB, and 70 dB, and the dotted line shows the measured value for LCL of 7 dB. The calculated values were obtained from Eqs. (19) and (20) using the measured differential mode signal level and the LCL value. In the calculation, Z_1 of 150 ohms and Z_0 of 100 ohms were used as typical values. Figure 11 shows that the calculated value almost agrees with the measured value. The interference field is about 10 dB lower than the proposed limits of 35 dBμV/m, even if

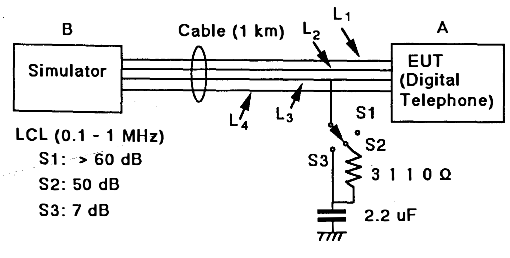


Fig. 10 Experimental layout for measuring the field strength caused by telecommunications signal.

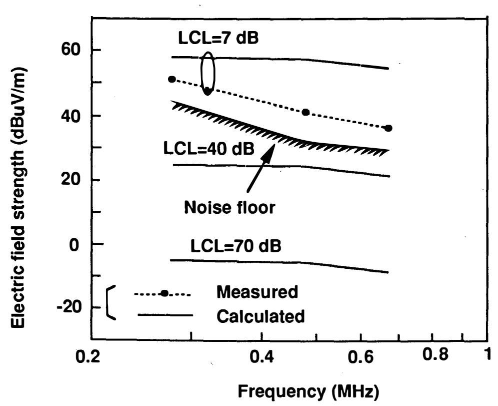


Fig. 11 Relationship between LCL of the telecommunications line and electric field strength.

the LCL is the worst case of 40 dB at the ISDN basic access interface bus line [13].

Common mode voltages exceeding 50 dBμV were observed, but these were still about 20 dB lower than the proposed limits shown in Table 1.

These results show that the interference field strength and the common mode voltages caused by the conversion from the signal's differential mode voltages can be calculated from Eqs. (19) and (20), and are smaller than the proposed limits.

5. 3 Estimation of the Interference Field Caused by Actual Equipment

The signal's common mode voltages may change according to the operating mode of the equipment. The signal's differential mode voltages were then measured using ISDN terminals, and the signal's common mode voltages and the interference field were estimated.

Quasi-peak and average values of the signal on the ISDN basic access interface bus line were measured using a digital telephone and a digital facsimile. Figure 12 shows an example of the measured signal's differential mode voltage. In this estimation, the first three peak frequencies shown in Fig. 12 were selected and the signal's quasi-peak and average values were measured for several operating modes of the equipment. The operating modes are dialing, ringing and communication for telephone, and sending photograph, large characters and small characters for facsimile.

In the estimation, the LCL was 45 dB, the common mode impedance was 150 ohms and the differential mode impedance was 110 ohms. The LCL of 45 dB corresponds to 80% cumulative probability when eight ISDN customer items of equipment (each LCL is at least 54 dB) are connected to the ISDN bus interface line [13]. Using Eqs. (19) and (20), the electric field strength (10 m away from the cable) is estimated. The estimation result is shown in Table 4. Table 4 shows that the electric field strength radiated from the telecommunications line is less than 35

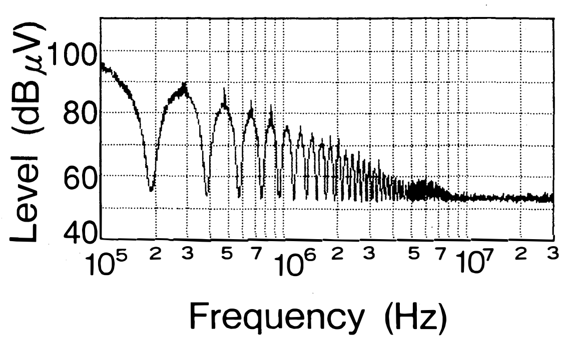


Fig. 12 Example of measured differential mode voltage.

Table 4 Estimated electric field strength of the equipment connected to ISDN basic access interface.

	Operating mode	Electric field strength(10 m distance) (dBuV/m)		
		0.29 MHz	0.48 MHz	0.67 MHz
Digital telephone	Dialing	15	16	13
	Ringing	14	15	13
	Communi-cation	15	16	13
Digital facsimile	Photograph	21	24	18
	Large characters	12	12	13
	Small characters	21	23	18

dBμV/m for each operating mode of the equipment.

This result shows that the interference field strength caused by the conversion from the signal's differential mode voltage is smaller than the proposed limits regardless of the operation mode of the equipment provided that the ISDN system meets the requirements for LCL specified by ITU-T (former CCITT) [14].

6. Conclusion

We have measured the electromagnetic field radiated from a telecommunications line and estimated the amount of conversion from a signal's differential mode voltages to common mode voltages. The measurement and estimation results show that the interference field strength radiated from telecommunications line almost meets the CISPR limits if the telecommunications equipment meets the limits of conducted common mode disturbances at telecommunication ports. The limits at telecommunication ports proposed by CISPR are effective in restricting the electromagnetic noise and in suppressing the interference to radio reception. The investigation also showed that the interference field caused by digitally transmitted signals on the ISDN basic access interface bus line is below the CISPR limits if the ISDN system meets the requirements for LCL.

In the future, the measurement accuracy should be improved.

Acknowledgements

The authors would like to thank Mr. Yasutaka Imori, Dr. Ken-ichi Kitami and Dr. Masamitsu Tokuda for their guidance and encouragement.

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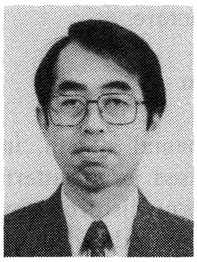

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