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TOYOTA ENGINEERING STANDARD

NO.: TSC7006G

TITLE: Bench test methods for electromagnetic interference susceptibility of automotive electronic equipment

CLASS: C1

Established/Revised: Rev. 5 (Dec. 2010)

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TOYOTA ENGINEERING STANDARD	TSC7006G	CLASS C1

Bench test methods for electromagnetic interference susceptibility of automotive electronic equipment

1. Scope

This standard covers the guideline of the test methods to evaluate Immunity performance (against EMI: Electromagnetic Interference) of automobile electronic equipment and also concept to be used when test methods and conditions are discussed and agreed among the related departments. The test methods cannot be covered in a single uniform way, because the importance and the influence level of the installing situation and the function of automobile electronic equipment are various varieties. The examination method may be changed from the content of this standard according to the equipment. The characteristic and the installing environment (if expansion for multi-purpose is planned, cover all possibilities) of test specimen are examined closely enough and the actual examination method is decided.
The frequency range covered in this standard is 1 to 2000 MHz.

2. Definitions

For the purpose of this standard, the following definitions shall apply.

(1) Automotive electronic equipment
It refers to the equipment used to control vehicle systems mainly by means of semiconductors, and various types of detectors (or sensors), output devices (or actuators), etc. to be used in combination with the above mentioned control equipment.

(2) Specimen
The specimen refers to the component of the automotive electronic equipment to be used for the test.

(3) Electromagnetic Interference susceptibility (Immunity performance)
It refers to the capability of electric/electronic equipment to meet the design specifications against electromagnetic waves.

(4) Critical filed strength for actuation
It refers to the lowest filed strength at which the electric/electronic equipment that has been meeting the design specifications can no longer meet the specifications with the irradiation of electromagnetic waves.

(5) Standard state
It refers to the ordinary atmosphere of test site, which shall be in the ordinary temperature range (5 to 35 °C) and ordinary atmospheric pressure range of 86 to 106 kPa, unless otherwise specified.

(6) Standard voltage
It refers to the power supply voltage for the specimen in ordinary tests and 10 to 16 V shall be used for 12 V parts and 20 to 32 V for 24 V parts. It is based on the premise that automotive battery is used, however, if driving of the specimen with such battery is difficult or not appropriate, the rated voltage supply or the rated voltage supply with the battery may be used.

(7) Modulation
As electromagnetic waves to be used in this standard, continuous wave (CW), amplitude modulation (1 kHz, percentage modulation 80 %) and pulse modulation (PM, On time: 577 μs, cycle: 4600 μs) shall be used.

(8) Engine compartment
In this standard, this term refers to a generic name of a place where there is no possibility that a handy transceiver or mobile phone comes close.

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(9) Cabin, trunk
It refers to not only cabin and trunk room but also a place where there is a possibility that a handy transceiver or mobile phone is brought in and its electromagnetic wave is transmitted.

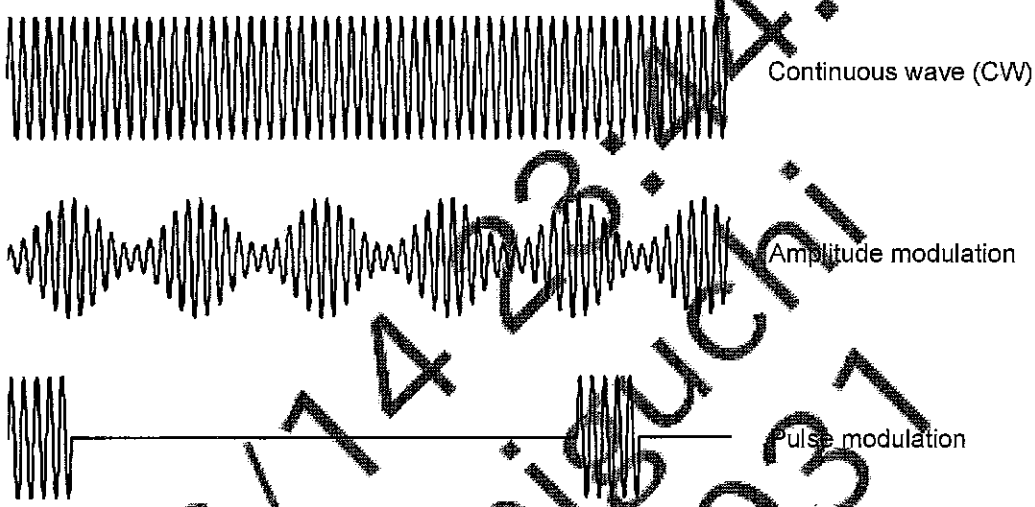


Fig. 1 Conceptual Diagram of Modulation

3. Test Steps
The following steps shall be taken in that sequential order for each test.
(1) Preparation
(a) Selection of test method
(b) Operation mode and decision of judgment method
(c) Preparation of test equipment, etc.
(d) Implementation of calibration
(2) Testing
(a) Setting specimen and test bench
(b) Implementation of test

4. Preparation for Testing
4.1 Selection of Test Method
The test methods covered in this standard are the following 6 methods, with characteristics for each method shown in Table 1. Provided that the frequencies to be used in testing shall be within the ranges that can be measured with the test equipment concerned.
The selection of test method shall be in line with the specifications of the specimens concerned. If the test is conducted for equipment installed where there is no possibility that antennas for handy radio or mobile phones are located near, or if the test is conducted for the limited antenna nearby direction, the radio equipment antenna nearby test and a part of mobile phone antenna nearby test may be omitted based on the agreement between the related departments. However, proximity to wiring harnesses (hereinafter referred to as "W/H") and 1880 MHz mobile phone antenna nearby test must be carried out.

Table 1 Features of Each Test Method

Test method	Guideline for applicable frequency range (MHz)	Features
TEM cell test	1 to 400	Field irradiation to parts. Capable of evaluating direct noise intrusion into circuit. If the specimen cannot be tested due to size limitations, G-TEM cell may be used.
Bulk current injection (BCI) test	1 to 1000	Bulk current injection into W/H. Capable of evaluating individual noise intrusion into low impedance circuit.
Stripline test	1 to 400	Field irradiation to W/H. Capable of evaluating noise intrusion into high impedance circuit. Capable of evaluating large parts. The field may also be applied to the case for small parts.
Free field test	20 to 2000	Field irradiation to W/H and parts. Large facilities such as anechoic chambers are necessary. Lower limit frequency is restricted due to facility related limitations.
Radio equipment antenna nearby test	28, 50, 144, 430, 900, 1280	Simulation of carrying handy radio equipment in the cabin.
Mobile phone antenna nearby test	835, 900, 1750, 1880	Simulation of carrying mobile phone in the cabin. Airport radar beam can also be simulated at 1880 MHz.

Each frequency listed in Table 1 shall be used in the radio equipment antenna nearby test and the mobile phone antenna nearby test. Use all frequencies listed in Table 1 in the TEM cell test, the stripline test, the free field test and the BCI test, depending on their combination. For selection of test method, determine appropriate conditions through discussions among the concerned departments by taking into consideration the features of test method, the form of specimen, and installing conditions. For those parts that meet the conditions listed in Table 2, select the BCI test. If additional test is performed (by using the test frequencies of 1 to 20 MHz and 200 to 2000 MHz), the BCI test may be performed limiting the frequency range to 20 to 200 MHz.

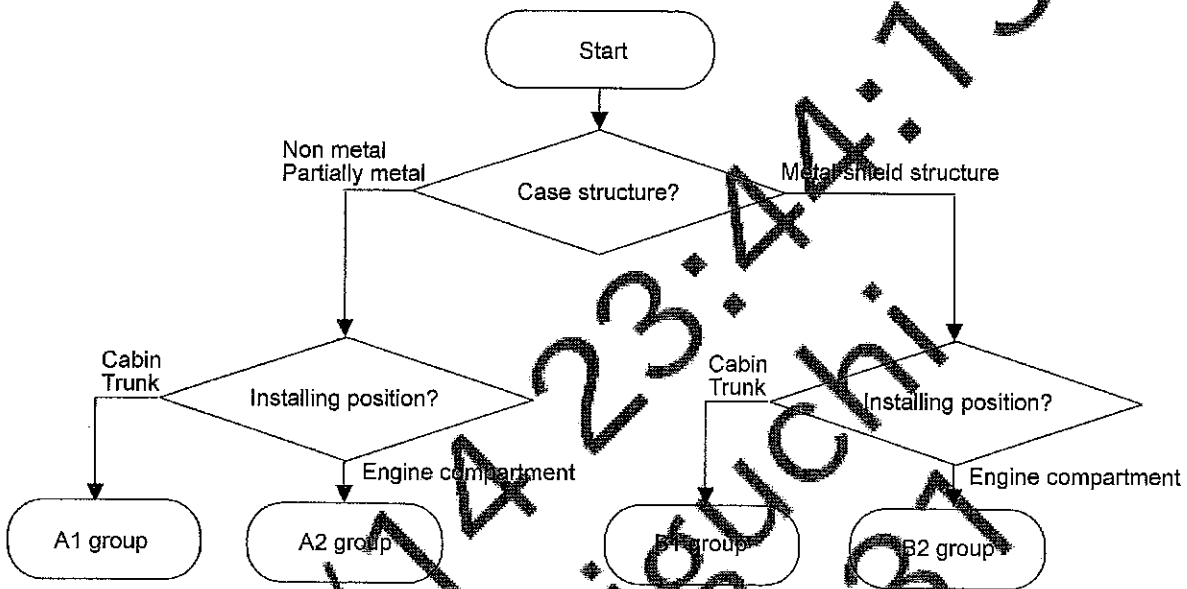
Table 2 Cases that Require BCI Test

No.	Condition	Remark
1	Having multiple grounds (for example, case ground, wire ground, power ground, signal ground and shielded ground line, etc.)	Detection of problems related to ground loop and common impedance.
2	Semiconductor relay and other low impedance parts	Evaluation of those parts with malfunctioning due to induced current rather than electric field.
3	Parts with negligible electric field induction to circuit board pattern and element	The circuit board size of 40 by 30 mm as the guide.
4	Parts securely shielded by metal case	Not TEM cell test but BCI test shall be conducted for the specimen whose intrusion route is W/H only.

Table 3 Test Frequencies (Unit: MHz)

1.0	24.8	37.8	60.2	99.4	150	234	375	577	894	1360
2.0	25.0	38.5	61.4	101	151	238	380	588	900	1380
3.0	25.2	39.2	62.6	103	154	240	382	599	911	1400
4.0	25.7	39.9	63.8	105	157	242	389	600	929	1420
5.0	26.2	40.6	65.0	107	160	246	396	610	935	1440
6.0	26.7	41.4	66.3	109	163	250	400	622	940	1460
7.0	27.0	42.2	67.6	111	166	255	403	634	947	1480
8.0	27.2	43.0	68.9	113	169	260	411	646	965	1500
9.0	27.7	43.8	70.2	115	172	265	419	658	984	1530
10.0	28.0	44.6	71.6	117	175	270	427	671	1000	1560
12.0	28.2	45.0	73.0	119	178	275	430	684	1020	1590
14.0	28.7	45.4	74.4	120	181	280	436	697	1040	1620
16.0	29.0	46.3	75.8	121	184	285	443	710	1060	1650
18.0	29.2	47.2	77.3	123	187	290	450	724	1080	1680
20.0	29.7	48.1	78.8	125	190	295	451	730	1100	1710
20.4	30.2	49.0	80.3	127	193	300	460	738	1120	1740
20.8	30.8	49.9	81.9	129	196	306	469	750	1140	1750
21.2	31.4	50.0	83.5	131	199	312	478	752	1160	1770
21.6	32.0	50.8	85.1	133	200	318	487	767	1180	1800
22.0	32.6	51.8	86.8	135	202	324	496	782	1200	1830
22.4	33.2	52.8	88.5	137	206	330	505	797	1220	1860
22.8	33.8	53.8	90.0	139	210	336	515	812	1240	1880
23.2	34.4	54.8	90.2	141	214	342	525	828	1260	1890
23.6	35.0	55.8	92.0	143	218	348	535	835	1280	1920
24.0	35.7	56.9	93.8	145	222	354	545	844	1300	1950
24.4	36.4	58.0	95.6	147	226	361	555	860	1320	1980
	37.1	59.1	97.5	149	230	368	566	877	1340	2000

Considering the above information, select the test to be performed by following the guideline shown in Fig. 2. However, some of the applicable tests may be omitted based on the design review and discussion on the circuit configuration, artwork, actual vehicle installation environment and production results by and among concerned departments. Table 4 shows selection examples and Table 5 shows the details of tests.



Test method	Frequency (MHz)	A1 group	A2 group	B1 group	B2 group
TEM cell	1 to 400	● (Case)(1)	● (Case)(1)	---	---
BCI	1 to 400	○ (W/H)	○ (W/H)	○ (W/H)	○ (W/H)
Stripline	1 to 400	○ (W/H)	○ (W/H)	○ (W/H)	○ (W/H)
Free field	400 to 2000	● (Case, W/H)	● (Case, W/H)	● (W/H)	● (W/H)
Radio equipment antenna nearby	28, 50, 144, 430, 900, 1280	● (Case, W/H)	● (W/H)	● (Case opening portion, W/H)	● (W/H)
Mobile phone antenna nearby	835, 900, 1750, 1880	● (Case, W/H)	● (Case(2), W/H)	● (Case opening portion, W/H)	● (W/H)

Fig. 2 Guideline for Test Method Selection

Notes:

(1) A G-TEM cell may be used if the test cannot be conducted with TEM cell due to the limitation of the specimen size. Limitation of the specimen size refers to a size that goes beyond the specimen setting range shown in Fig. 17.

(2) Perform irradiation only at 1880 MHz for simulation of air traffic control radar.

Remark: ●: Required; ○: Select one
Location(s) for electromagnetic wave radiation or bulk current injection is/are shown in parentheses.

Table 4 Examples of Test Method Selection

Figures indicate frequency (Unit: MHz)

Test method	Characteristics of specimen	TEM cell test	BCI test	Stripline test	Free field test	Radio equipment antenna nearby test	Mobile phone antenna nearby test
Case No.1	Installed in engine compartment Metal case	---	1 to 400	---	400 to 2000 W/H irradiation	28, 50, 144, 430, 900, 1280 Close to W/H portion	835, 900, 1750, 1880 Close to W/H portion
Case No.2	Installed in engine compartment Metal case High impedance circuit	---	---	1 to 400	400 to 2000 W/H irradiation	28, 50, 144, 430, 900, 1280 Close to W/H portion	835, 900, 1750, 1880 Close to W/H portion
Case No.3	Installed in engine compartment Resin case	1 to 400	1 to 400	---	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to W/H portion	835, 900, 1750 Close to W/H portion
							1880 Close to both W/H and case(3)
Case No.4	Installed in engine compartment Composite case Multiple grounds	1 to 400	1 to 400	---	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to W/H portion	835, 900, 1750 Close to W/H portion
							1880 Close to both W/H and case(3)
Case No.5	Installed in cabin Resin case Large part	1 to 400 G-TEM cell	20 to 200(4)	---	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to both W/H and case	835, 900, 1750, 1880 Close to both W/H and case
Case No.6		---	20 to 200(4)	1 to 400	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to both W/H and case	835, 900, 1750, 1880 Close to both W/H and case
Case No.7	Installed in cabin Resin case	1 to 400	20 to 200(4)	---	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to both W/H and case	835, 900, 1750, 1880 Close to both W/H and case
Case No.8	Installed in cabin Resin case Small part	---	1 to 400	---	400 to 2000 Irradiate both W/H and case	28, 50, 144, 430, 900, 1280 Close to both W/H and case	835, 900, 1750, 1880 Close to both W/H and case
Case No.9	Installed in cabin Metal case	---	1 to 400	---	400 to 2000 W/H irradiation	28, 50, 144, 430, 900, 1280 Close to W/H and case opening portion	835, 900, 1750, 1880 Close to W/H and case opening portion

Notes:

(3) Also, move the antenna close to the case as an alternative test for radar beam intrusion into engine compartment.

(4) Test shall be conducted if marked item is applicable to Table 2.

Table 5 Details of Each Test Method

Test method	Variation	Modulation
TEM cell test	Apply the electric field load to the case in the X, Y and Z directions.	CW and AM
BCI test	All terminals at once, each W/H branch and each circuit (open collector circuit, feedback circuit for voltage and current, each GND)	CW and AM
Stripline test	Applicable to W/H in high impedance circuit.	CW and AM
Free field test	As specified in Table 6.	As specified in Table 6.
Radio equipment antenna nearby test	Sweep W/H for the distance equivalent to $\lambda/2$ from the part surface and the case. However, the surface of any part to which no handy radio equipment is likely to come close in the actual vehicle installation environment may be omitted.	CW
Mobile phone antenna nearby test	Sweep W/H for the distance equivalent to $\lambda/2$ from the part surface and the case. However, the surface of any part to which no mobile phone is likely to come close in the actual vehicle installation environment may be omitted.	CW and PM

Table 6 Examples of Free Field Test Selection

Test No.	Frequency (MHz)	Antenna position	Polarization	Modulation	Direction of specimen	Aim
1	400 to 1000	Front of W/H	Vertical	AM	Any chosen direction	Acquisition of EMC certification
2	800 to 2000	Front of specimen	Vertical	PM	Any chosen direction	Acquisition of EMC certification
3	400 to 2000	Front of specimen	Vertical	CW	X, Y and Z directions. (See Fig. 18)	Irradiation to specimen
4	400 to 2000	Front of specimen	Horizontal	CW	Any chosen direction	Irradiation to W/H

Remark: Test No.3 shall not be conducted for the specimen whose case has the metal shield structure.

Compile the above results into test plan, and obtain agreement of concerned departments. Table 7 shows the details of entries in the test plan.

Table 7 Details of Test Item Entries

Item	Details
Specimen information	Specimen name, case structure, external dimensions and system configuration
Vehicle installation environment	Installing position, W/H length, bracket and grounding treatment Surrounding metal parts and trims, etc.
Test method	Selected test method and reason(s) for selection Applicable frequency and modulation method for each test method
Irradiation time	Irradiation time for each frequency and its validity
Test layout	Layout for each test method
Bench configuration	Actual load or simulated load Cable length, type and diameter of sub-W/H Simulator configuration Bracket and grounding treatment Battery or constant-voltage power supply (power supply voltage)
Irradiation surface	Free field test
Injection terminal	Grouping for BCI test and its validity
Conditions of radio equipment antenna nearby test and mobile phone antenna nearby test	Surface where antenna is nearing and nearing approach (including validity of sweeping method and sweeping speed) Reproduced condition of actual vehicle installation environment and validity of antenna power and nearby distance
Operating conditions and criteria	Each operation mode and functional rank, test level and operation class (See Attached Table 1)
Items for discussion and agreement	Items for discussion and agreement

4.2 Determination of Operation Mode and Judgment Method

Take the following steps to determine the operation mode and judgment method for a specimen when performing the test.

(1) Identify all functions of the specimen.

(2) Subdivide the functions of the specimen, and classify the importance of each function in accordance with Table 8.

(3) For each function, determine the operating conditions and the judgment method for each test level in accordance with Tables 9 and 10. For class B, clearly define the acceptable range.

(4) Compile the results into a list, and obtain agreement of concerned departments. An example of the list is shown in Attached Table 1.

Table 8 Guideline for Importance Classification (Functional Rank)

Rank	Function	Example of function
Rank "イ" (i)	(a) Directly affects vehicle travel	(i) Vehicle speed control (engine power, transmission shift, cruise control and speed limiter) (ii) Brake pressure control (iii) Change of steering wheel angle (iv) Driving posture (seat position, steering tilt/telescopically adjustable) (v) Securing field of vision (front wiper, flux distribution of headlamp)
	(b) Directly affects safety	Air bag control
	(c) Affects travel of other road users	(i) Exterior lamps (ii) Sound production to vehicle exterior (horn and alarm)
	(d) Affects data of laws and regulations	Odometer and tachograph
	(e) Data bus related with above	CAN communication
	(f) Display of warning related to above	Warning lamp and warning buzzer
	(g) Related to security	Door lock release and electronic road pricing
Rank "ロ" (ro)	(h) Leading to vehicle failure (i) Leading to the image of deteriorated vehicle safety	(i) Functions for protection of vehicle reliability (ii) Warning lamp illumination not ranked "イ" (i) (iii) Function involving complaint case(s) in the past
Rank "ハ" (ha)	(j) Any function rank not ranked "イ" (i) or "ロ" (ro) that can be identified by users	Display of information not directly related to running, and sound production in the cabin
Rank "ニ" (ni)	(k) Any function not ranked "イ" (i) or "ロ" (ro) that involves user's operation not directly related to driving	(i) Operation to lower power window (ii) Switching between various modes for audio
Rank "ホ" (ho)	(l) Any function difficult to identify because the effect is minor (m) No effect to user in consideration of usage and frequency	(i) Operation of air purifier (ii) Operation of light reminder
Rank "ヘ" (he)	(n) Function for servicing or at plant (o) No effect on users	Diagnosis readout

Table 9 Operation Mode Classification

Class	Details
Class A	During and after the interference, all functions of the part/system operate properly as designed.
Class B	During the interference, one function of the part/system does not operate as designed, but operates within its permitted limit. When the interference is eliminated, this function automatically returns to normal.
Class C	During the interference, one function of the part/system does not operate as designed, but automatically returns to normal when the interference is eliminated.
Class D	During the interference, one function of the part/system does not operate as designed. When the interference is eliminated and a simple adjustment is made, it operates normally.

Table 10 Guideline for Functional Rank, Test Level and Operation Class

Functional rank	Operation class			
	Test level I	Test level II	Test level III	Test level IV
Rank "イ" (i)	Class B(5) (Class A)	Class A	Class A	Class A
Rank "ロ" (ro)	Class C	Class A	Class A	Class A
Rank "ハ" (ha)	Class C	Class B(5) (Class C)	Class A	Class A
Rank "ニ" (ni)	Class D	Class C	Class B(5) (Class C)	Class A
Rank "ホ" (ho)	Test is not necessary	Class D	Class C	Class B(5) (Class C)
Rank "ヘ" (he)	Test is not necessary	Test is not necessary	Test is not necessary	Test is not necessary

Note (5): For the function that can not simply define On or Off, use the class specified in ( ).

4.3 Test Bench Preparation

Test bench shall be basically equal to actual vehicle setting, facilities used for testing shall be as follows. Carry out the test in standard conditions and at standard voltages, unless otherwise specified.

(1) Simulator

Use a simulator to monitor the state of specimen actuation and to apply a proper load equivalent to that on the vehicle. The configuration of the simulator shall meet the specifications of each specimen. Use a simulator to which countermeasures (such as insertion of ferrite core, storage into shield case, use of optical fiber for communication line with monitor portion) are implemented to have resistance against electromagnetic interference.

(2) Sub-wire harness

Use a sub-wire harness to connect the specimen, simulator and the power supply. The type and diameter of the cable for the sub-wire harness shall be equivalent to that on the vehicle. If there are some other specifications for a particular specimen, follow the specifications.

(a) If W/H is protected from noise using shielding wire etc., incorporate the condition in the test bench.

(b) The length of the sub-W/H shall be the same as in the actual vehicle. Otherwise, artificial network (AN) may be connected 1 to 1.5 m from the specimen to reduce the effect due to interference between power supplies.

(3) Artificial network (AN)

The power shall be supplied to the specimen through the artificial network (AN) with the circuit configuration shown in Fig. 3. The impedance characteristics shall not deviate more than 20 % from those shown in Fig. 4.

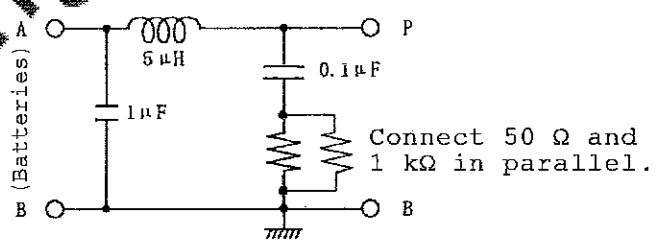


Fig. 3 Artificial Network (AN) Circuit Configuration

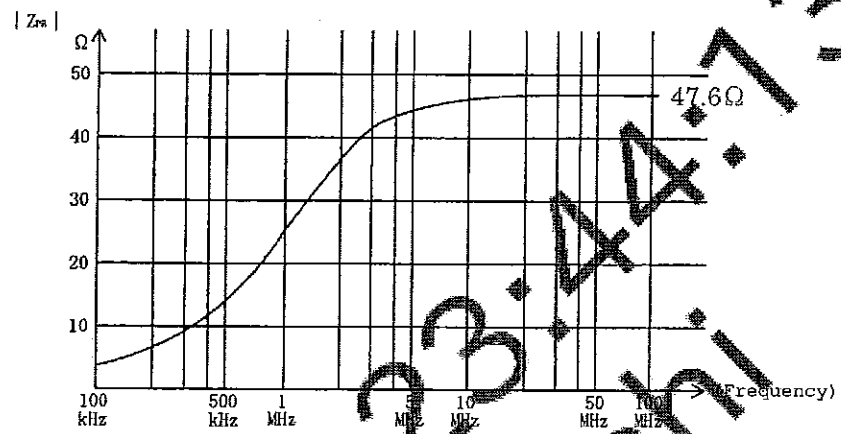


Fig. 4 Frequency Characteristics (A-B Short Circuited) of Artificial Network (AN)

(4) Ground plane
The ground plane used in free field test shall be 0.5 mm or more in thickness, and its material shall be copper, brass, galvanized steel, or aluminum.
The ground plane shall have an area of 2.25 m² or more, and distance of 100 mm or more from the edge of ground plane when the specimen, simulator, AN and batteries are placed. Also, the shortest side shall be 1 m or longer.

(5) Grounding cable
The grounding cable used in free field test shall have a DC resistance of 2.5 mΩ or less.

(6) Test table
The table on which the specimen and sub-W/H are placed shall be made of a non-conductive material such as wood.

(7) Antennas (for radio equipment antenna nearby test and mobile phone antenna nearby test)
(a) Antenna for 28 MHz
Use a λ/4 mobile antenna or a broadband antenna sold on market in the 28 MHz frequency radio equipment antenna nearby test. A recommendable antenna is shown in Table 11.
(b) Antenna for 50 MHz
Use a λ/4 mobile antenna sold on market in the 50 MHz frequency radio equipment antenna nearby test. A recommendable antenna is shown in Table 11.

Table 11 Recommendable Test Equipment

No.	Name of measuring device	Maker & model No.	Characteristics (MHz)	Quantity
1	TEM cell	Kyoritsu Denshi: KTC-502 (Special)	DC: up to 400	One set
2	Injection probe and calibrator (BCI test)	TSJ: TSBC-140	0.1 to 1000	One set
		TSJ: TSBC-CF-1	0.01 to 400	One set
		TSJ: TSBC-CF-2	0.1 to 1000	One set
3	Stripline	Conforms to ISO 11452-5	0.01 to 400	One set
4	Broadband antenna (Free field test)	Amplifier Research: AT4001	400 to 1000	One set
		Amplifier Research: AT4002	800 to 2000	One set
5	28 MHz mobile antenna	Diamond: CR-11	28	One set
6	50 MHz mobile antenna	Comet: SB14 or Diamond: CR-6 or DP-EL6	50	One set

(c) Antenna for 144 MHz

Use a λ/4 mono-pole antenna shown in Fig. 5 as the antenna for 144 MHz test to be used in the radio equipment antenna nearby test. If correlation is confirmed, a λ/4 short antenna shown in Fig. 6 may be used. Select a proper antenna so that VSWR≦1.5 can be attained with the coaxial cable connected.

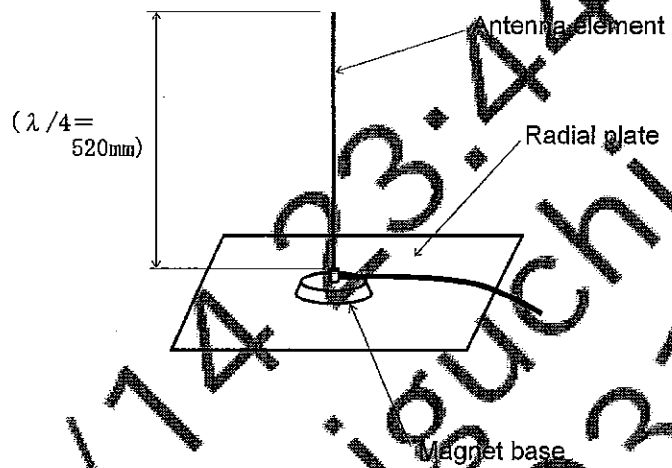


Fig. 5 Example of Configuration of λ/4 Mono-pole Antenna

Remark: Recommended configuration is as follows: antenna element: brass rod with an approx. 2 mm diameter; radial plate: approx. 0.6 mm thick iron plate; magnet base: use a magnet base sold in the market.

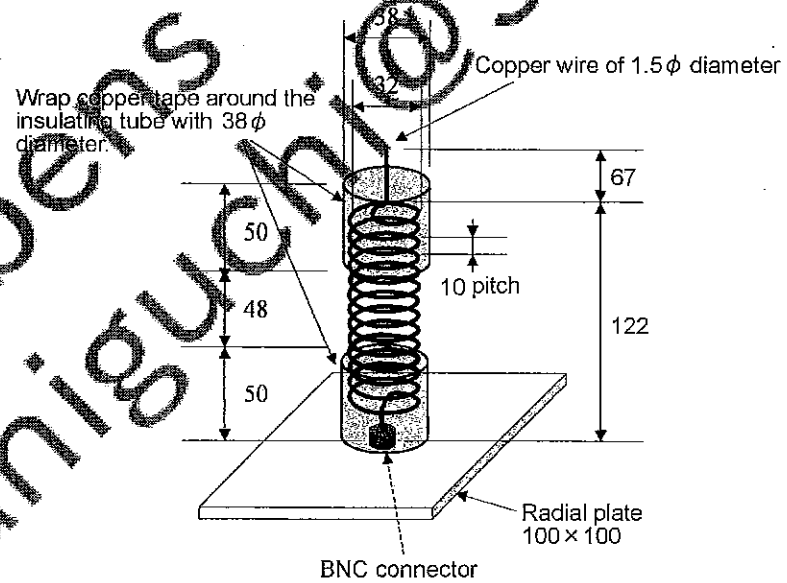


Fig. 6 Example of Configuration of λ/4 Short Antenna (Unit: mm)

(d) Antenna for 430 MHz or more

Use a λ/4 sleeve antenna for a test frequency of 430 MHz or more in the radio equipment antenna nearby test and the mobile phone antenna nearby test. Fig. 7 shows an example of the structure, and Table 12 shows examples of element length and sleeve length. Select a proper antenna so that VSWR≦1.5 can be attained with the antenna fixed and the coaxial cable connected in the same manner as in testing.

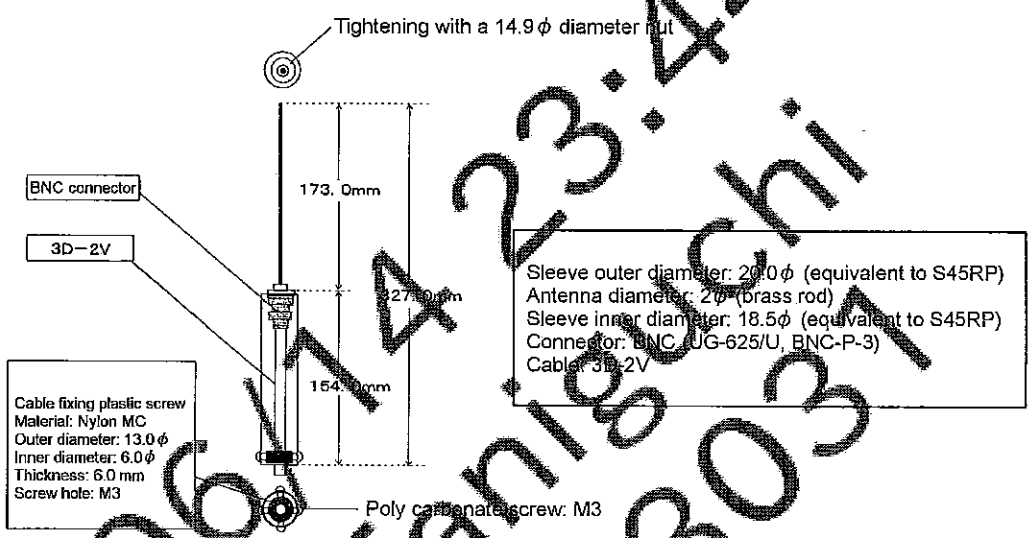


Fig. 7 Example of λ/4 Sleeve Antenna Configuration

Table 12 Example of λ/4 Sleeve Antenna Element Length and Sleeve Length

Frequency (MHz)	Antenna element length (mm)			Sleeve length (mm)		
	No.1	No.2	No.3	No.1	No.2	No.3
430	173	174.5	177.9	154	154	156
835	90	90	89	79.5	79	81
900	83	83	82	74.5	74	75
1280	58	58	58.5	52	51.5	53
1750, 1880(6)	42	42	41.5	35	34.5	36.5

Note (6): One and the same antenna may be used for two or more frequencies, as long as the specified VSWR can be attained.

(e) Attenuator for matching
An attenuator may be inserted between the power amplifier and the antenna to protect the former because the specimen and the antenna come close to each other to worsen the VSWR in the radio equipment antenna nearby test and the mobile phone antenna nearby test. When inserting an attenuator, insert the power meter and the VSWR meter between the attenuator and the antenna or compensate for the attenuator's insertion loss (Fig. 8).

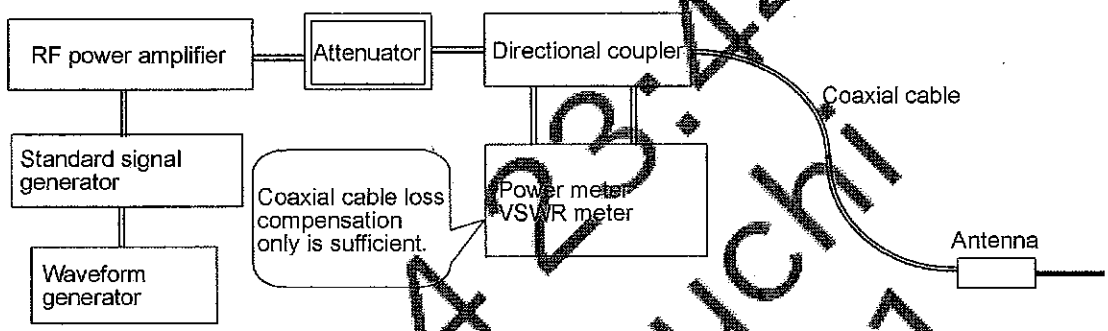


Fig.8-(a) When inserting attenuator between power amplifier and directional coupler

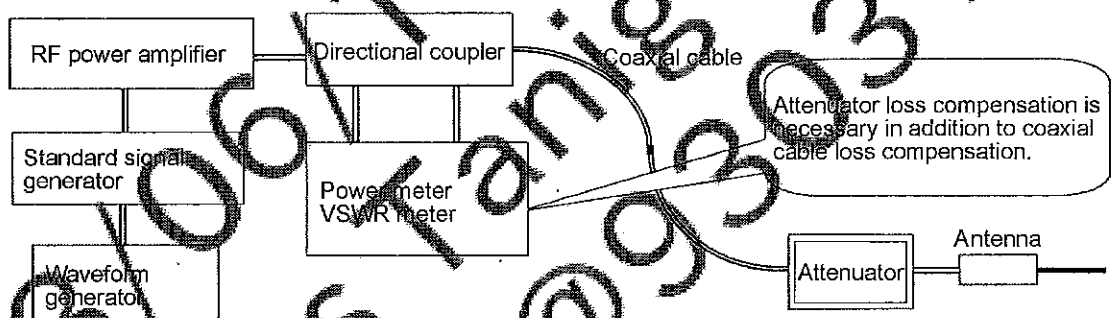


Fig.8-(b) When inserting attenuator between directional coupler and antenna

Fig. 8 Example of Attenuator Insertion to Secure VSWR

4.4 Implementation of Calibration
Carry out calibration taking the steps below to establish the reference electric field for testing.
(1) Install electric field probe(s) (current probe for BCI test) in accordance with the specifications for each test.
(2) Unless otherwise specified, adjust the RF power amplifier output properly so that the electric field strength and the injection current attain the values shown in Table 13. When carrying out calibration, use the same frequency as the test frequency specified in Table 3.

Table 13 Example of Calibration Target Values for Electric Field Strength and Injection Current

Test method	Target values
TEM cell test (V/m)	200, 100, 60, 30
BCI test (mA)	Lump-sum input: 200, 100, 60, 30 Each input: 160, 80, 50, 25
Stripline test (V/m)	200, 100, 60, 30
Free field test (V/m)	200, 100, 60, 30
Radio equipment antenna nearby test	28 MHz: 100, 200 V/m
Mobile phone antenna nearby test	Other than 28 MHz: Specified in antenna power

(3) Measure the values of all items listed below at every test frequency.
(a) Forward power (W1)
(b) Reflection wave power
(c) VSWR (voltage standing wave ratio)
(d) Signal generator output
(e) Generated field strength (injection current for BCI test)
For calibration, use unmodulated signals (CW).

Carry out calibration at a frequency of one or more a year, and check for any change in (3) (a) to (e). If any change is detected, clearly identify problem(s) in facilities, and take appropriate steps. A simplified method may be used for daily check if there is a clear reason for it. If the differences in forward power between 100 and 200 V/m and between 100 and 200 mA are different from 6 dB, clearly identify the cause, take appropriate steps, and secure linearity of facilities.

4.4.1 Calibration Method for TEM Cell Test

Set the field probe at the location shown in Fig. 9, and carry out calibration.

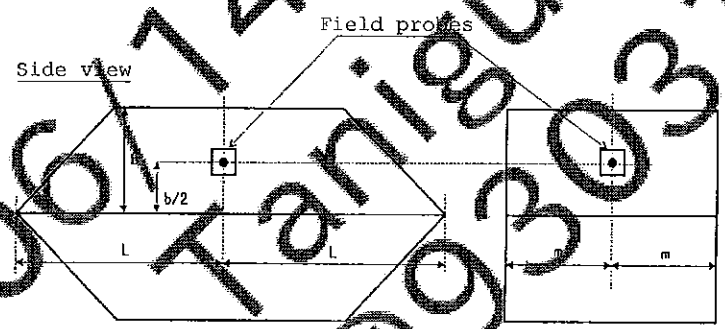


Fig. 9 Field Probe Locations upon Calibration for TEM Cell Test

4.4.2 Calibration Method for BCI Test

While closed loop method and substitution method are the 2 typical types of BCI test method, the substitution method is used in this standard. Set the injection probe as shown in Fig. 10.

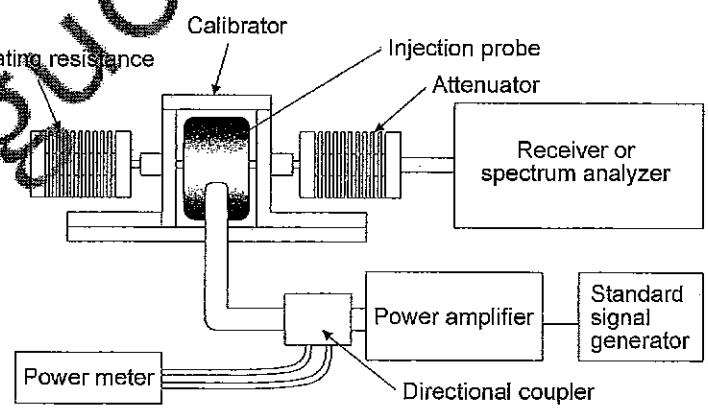


Fig. 10 BCI Calibration Basic Layout

4.4.3 Calibration Method for Stripline Test

Install an electric field probe at the location within the stripline, as shown in Fig. 11, and carry out calibration.

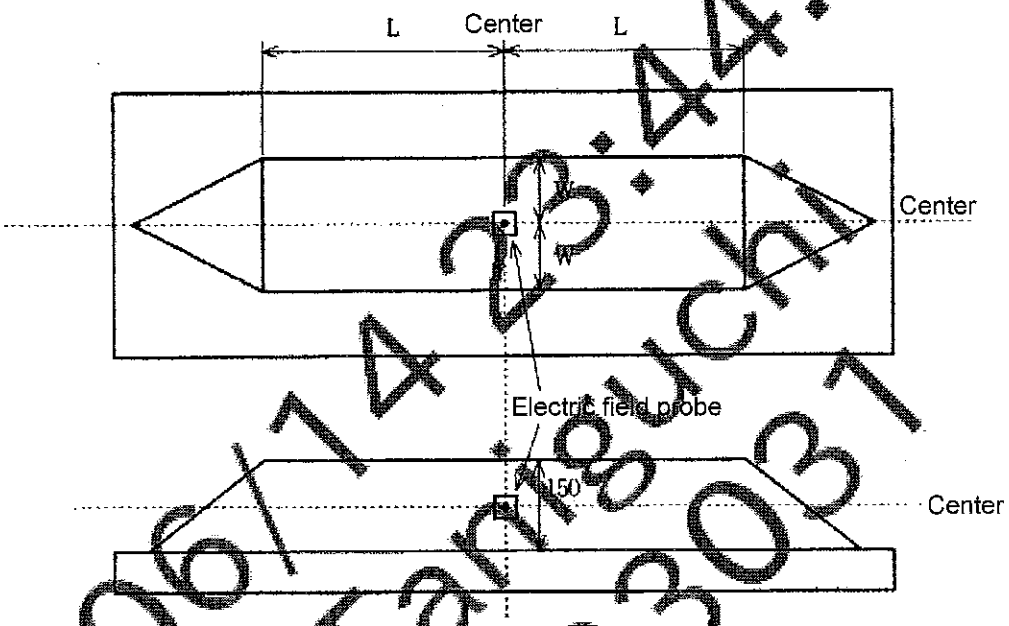


Fig. 11 Electric Field Probe Installation Location for Calibration in Stripline Test (Unit: mm)

If the electric field strength at 5 cm above the ground surface is required, the height indicated in Figs. 11 and 22 may be changed from the center to a height of 5 cm. Methods to calculate the electric field strength are as follows.

Examples:

1. Perform calibration using a small electric field probe that has no impact on the electric field distribution.
2. Measure the characteristic impedance of the stripline, and calculate the electric field strength using the equation.

4.4.4 Calibration Method for Free Field Test

(1) Front of W/H

Install electric field probes at 3 locations: the reference point, right reference point, and left reference point as shown in Fig. 12. The electric field strength at the right and left reference points shall not be less than 50 % of the field strength at the reference point. Test with vertical polarization.

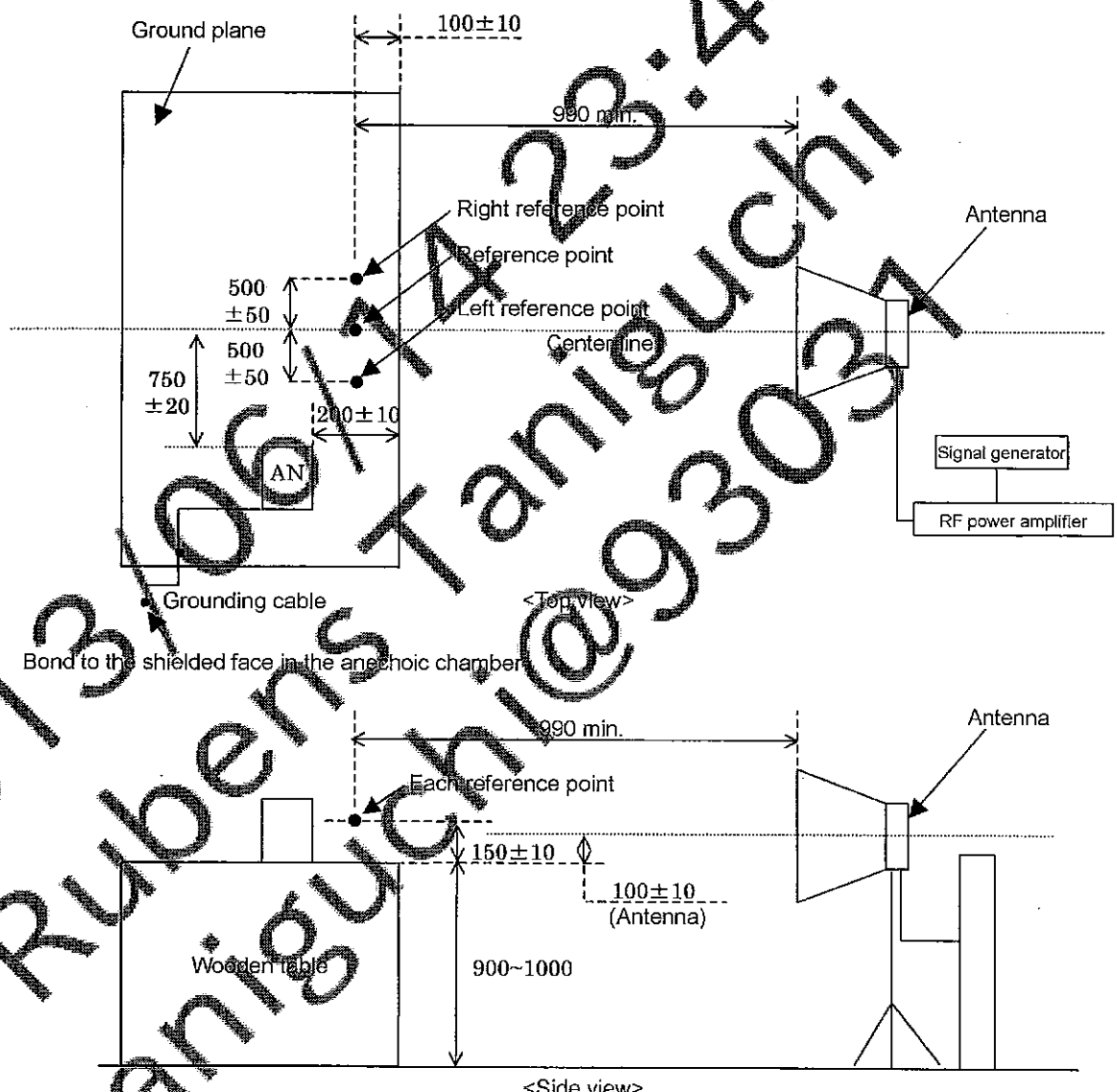


Fig. 12 Layout for Calibration in Free Field Test (Front of W/H) (Unit: mm)

(2) Front of specimen

Install electric field probes at 2 locations: the reference point and left reference point as shown in Fig. 13. The electric field strength at the left reference point shall not be less than 50 % of the field strength at the reference point. However, the left reference point may be moved closer to $\lambda/2$ from the reference point at high frequencies where the antenna directionality narrows. Perform the calibration on the respective polarization planes of horizontal and vertical polarization.

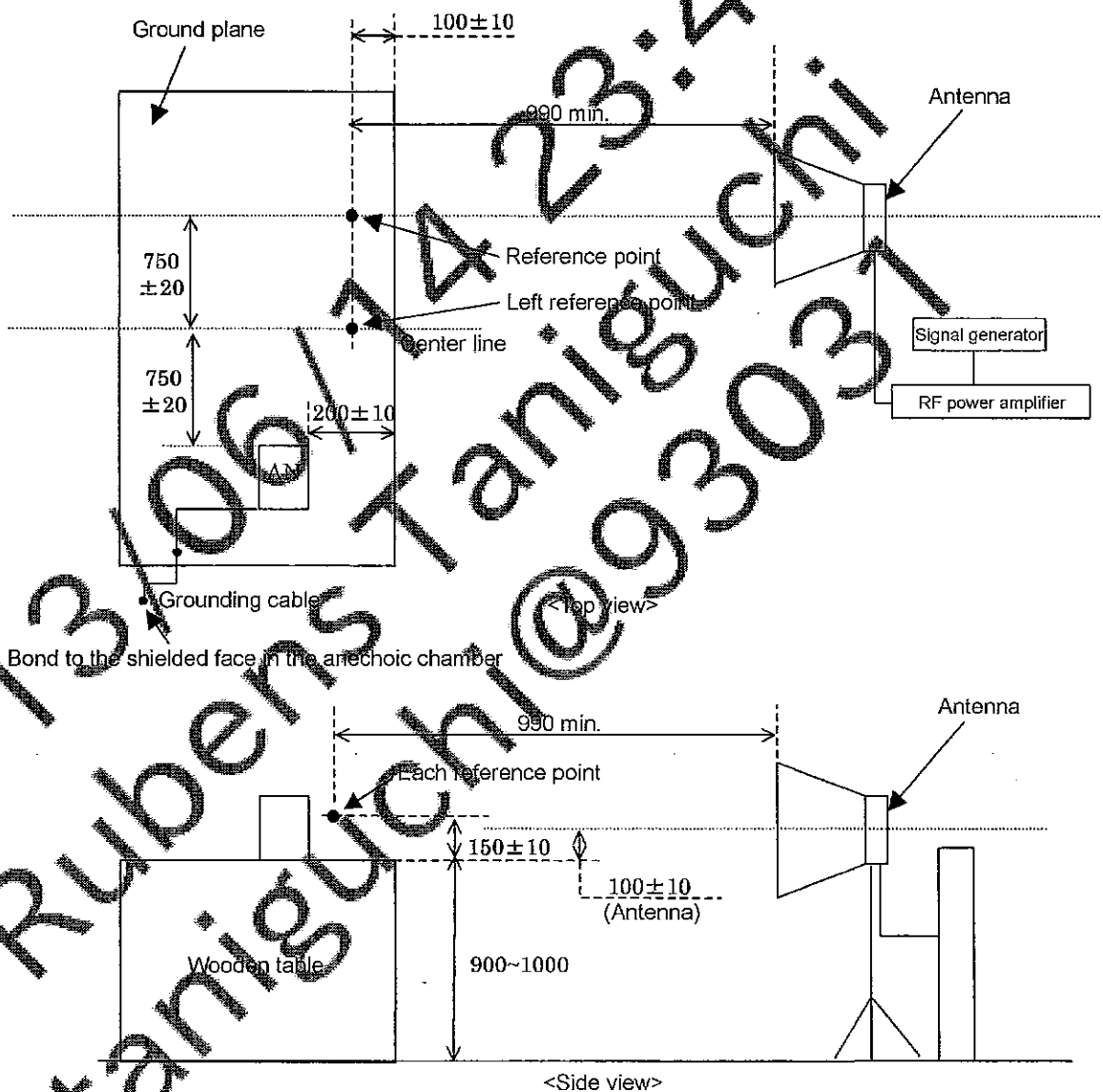


Fig. 13 Layout for Calibration in Free Field Test (Front of Specimen) (Unit: mm)

4.4.5 Calibration Method for Radio Equipment Antenna Nearby Test (28 MHz Test)

The radio equipment antenna nearby test for the frequency range of 50 MHz or more and the mobile phone antenna nearby test are performed by specifying the antenna output and distance, but the test is performed for a frequency of 28 MHz by specifying the electric field strength. Therefore, carry out calibration by following the procedures described below.

(1) Install an electric field probe at the location shown in Fig. 14. Select an appropriate 28 MHz mobile antenna so that the value of VSWR becomes 2.0 or less where no electric field probe is installed.
To secure VSWR of 2.0 or less, antenna tuner may be used or the ground plane may be grounded on the floor, wall or ceiling of the shield room.

(2) Adjust the RF power amplifier output properly so that the electric field strength meter shows the specified value at 28 MHz.

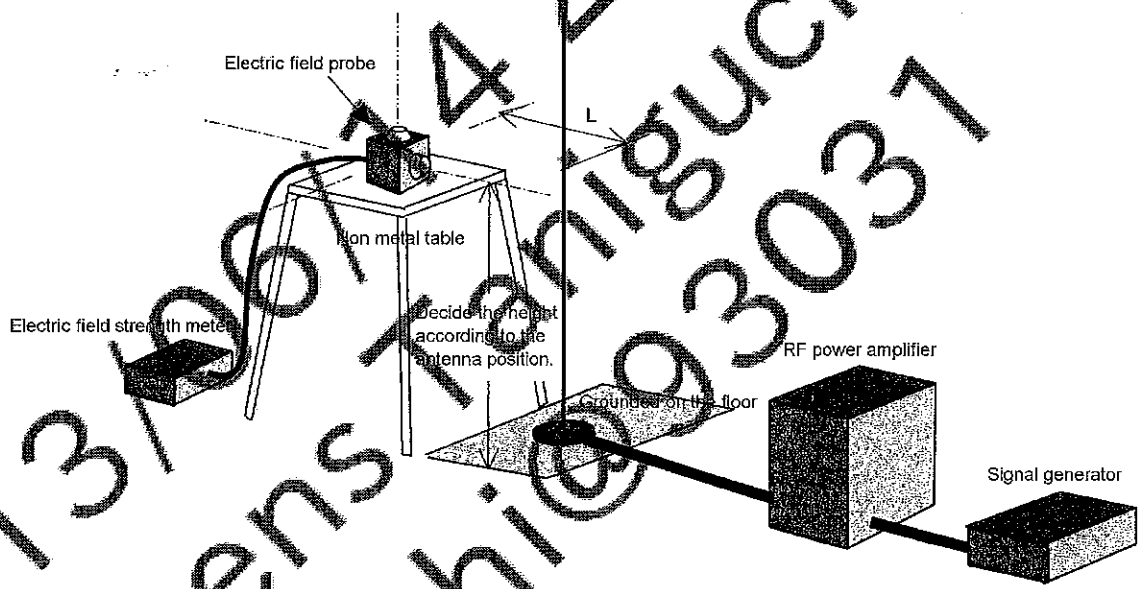


Fig. 14 Layout upon Calibration for Radio Equipment Antenna Nearby Test (28 MHz Test)

Remark: Set L at 0.3 m or longer.

4.4.6 Calibration Method for Radio Equipment Antenna Nearby Test (50 MHz Test)

Calibration of λ/4 mobile antenna itself is not necessary, and measure the power loss caused by the coaxial cable from the power meter to the antenna input [including the power loss caused by attenuator in the case where an attenuator is inserted between the directional coupler and the antenna in order to improve matching (securing VSWR) (Fig. 8 (b))].

4.4.7 Calibration Method for Radio Equipment Antenna Nearby Test (144 MHz Test)

Calibration of λ/4 mono-pole antenna itself is not necessary, and measure the power loss caused by the coaxial cable from the power meter to the antenna input [including the power loss caused by attenuator in the case where an attenuator is inserted between the directional coupler and the antenna in order to improve matching (securing VSWR) (Fig. 8 (b)].

4.4.8 Calibration Method for Radio Equipment Antenna Nearby Test (Test at 430 MHz or more) and Mobile Phone Antenna Nearby Test

(1) When FP2000/FP5000 (manufactured by AR) equivalent or HI6105/HI6005 (manufactured by ETS) equivalent is used

Set the antenna and the electric field probe as shown in Fig. 15.

Fig. 15 Calibration Layout When FP2000/FP5000 (Manufactured by AR) or Equivalent to HI6105/HI6005 (Manufactured by ETS) is Used

Set a proper antenna input power so that the electric field strength meter shows the value (resultant 3-axis value) as specified in Table 14.1. Calculate coaxial cable loss including antenna loss using equation (1) from the forward power thus determined in testing.

$$L = 10 \times \log_{10} (P_C \div P_S) \quad (dB) \text{ ----- (1)}$$

where,
L: loss by coaxial cable (dB) (including antenna loss)
P_C: forward power during calibration (W)
P_S: estimated antenna power (W)

Table 14 Calibration Reference Value for Sleeve Antenna (When FP2000/FP5000 (Manufactured by AR) or Equivalent to HI6105/HI6005 (Manufactured by ETS) is Used)

Frequency (MHz)	Estimated antenna power (W)	Calibration distance (mm)	Reference value (V/m)	
			When FP2000/FP5000 is used	When HI6105/HI6005 or the equivalent is used
430	15	50	300	300
835	2	50	90	120
900	10	50	180	230
	4	50	115	150
1280	2	50	---	100
1450	2	50		100
1880	2	50		90

(2) When FP2080 or FP5080 is used (for a frequency of 1 GHz or more)
If FP2080, FP5080 (both of them manufactured by AR) or other electric field probe for which the position of antenna element cannot be specified is used, set the antenna and the electric field probe as shown in Fig. 16.

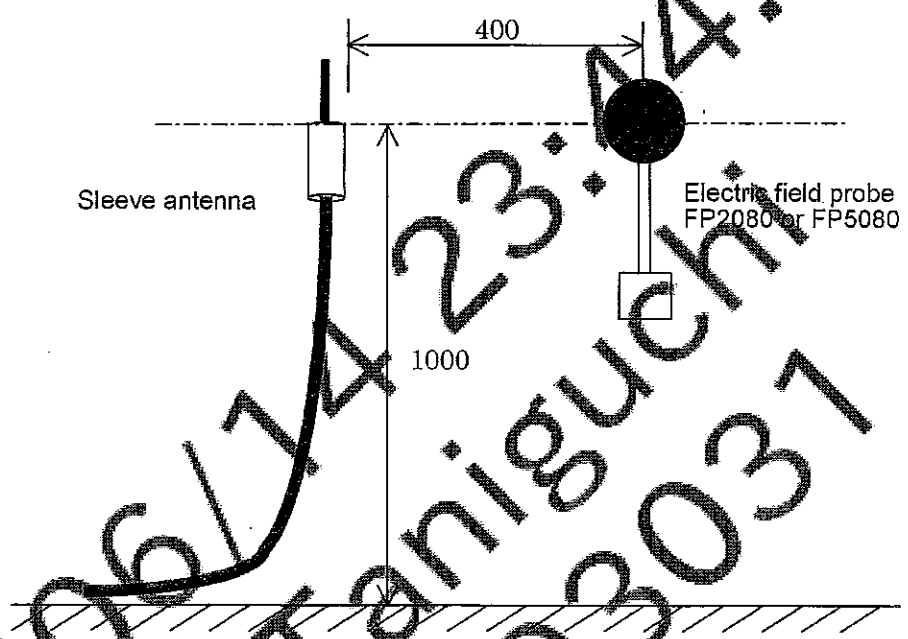


Fig. 16 Calibration Layout When FP2080 or FP5080 is Used (Unit: mm)

Set a proper antenna input power so that the electric field strength meter shows the value (3 axes combined value) as specified in Table 15. Calculate coaxial cable loss including antenna loss using equation (2) from the forward power thus determined in testing.

$$L = 10 \times \log_{10}(P_C \div P_S) \quad (dB) \quad \text{---(2)}$$

where,
L: loss by coaxial cable (dB) (including antenna loss)
P_C: forward power during calibration (W)
P_S: estimated antenna power (W)

Table 15 Calibration Reference Value for Sleeve Antenna (When FP2080 or FP5080 is Used)

Frequency (MHz)	Estimated antenna power (W)	Calibration distance (mm)	Reference value (V/m)
1280	2	400	21
1750	2	400	24
1880	2	400	27

4.5 Tests

(1) Modulation of electromagnetic wave for test

The electromagnetic waves shall conform to the provisions in Table 5. Conform to the below for test modulation methods.

(a) AM modulation

Adjust the RF amplifier output properly so that the output does not become lower than the forward power (W) based on the forward power (W1) set in the calibration for each test.

W (dBm) = W1 (dBm) - 5.1 dB ----- (3)

After determining the RF power amplifier output, generate the modulating signal specified below. 1 kHz sine wave AM modulation of 80 %

(b) Pulse modulation

Adjust the RF power amplifier output so that at least the forward power (W1) that has been set during calibration for each test is reached. After determining the RF power amplifier output, generate the modulating signal specified below. Pulse modulation with ON time of 577 μs and cycle of 4600 μs

(2) Functionality checking of specimen

Adjust the RF amplifier output per test frequency properly so that the output does not become lower than the forward power measured upon calibration for each test (follow (1) if modulation exists). Then check that the operation of the specimen meets its specification requirements. Electromagnetic wave radiation time at each frequency shall basically be as specified for each specimen except for the minimum radiation time, which shall be 2 s.

(3) Measurement of malfunctioning limit level

If the operation of the specimen does not meet specification requirements in the test reference field, measure critical field strength for actuation (the minimum inoperable antenna distance for the radio equipment antenna nearby test and the mobile phone antenna nearby test and the minimum inoperable current for the BCI test, hereinafter referred to as the "limit level").

Measure the limit level as described below.

(a) Lower the power to a level where the specimen operates as required in the specification.

(b) Then, increase the power to a level that the specimen does not operate as required in the specification. Obtain the electric field strength (or the antenna distance or the injection current) at the power of this moment.

4.5.1 TEM Cell Test

(1) Specimen and test bench setting

Set the specimen within the range shown in Fig. 17. It is acceptable as long as the circuitry units such as the substrate of specimen stay within the range. Apply the field in X-axial, Y-axial and Z-axial directions as shown in Fig. 18.

If the size of the specimen is bigger than the specified range, consult separately. Connect the specimen to the simulator through the sub-wire harness. Set the sub-wire harness in the cell vertically (in the direction of field) against the specimen with the shortest possible distance. Use an ECU bench made of a material with a dielectric constant of 1.4 or smaller. The test bench configuration is shown in Fig. 19. Select a specified electric filed strength for each specimen from Table 16 according to each test level. Test shall be conducted in directions corresponding to each X-axial, Y-axial and Z-axial directions with respect to the field application directions.

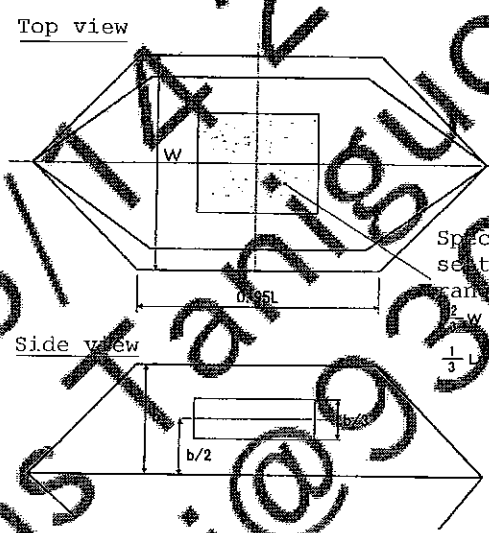


Fig. 17 Specimen Setting Range

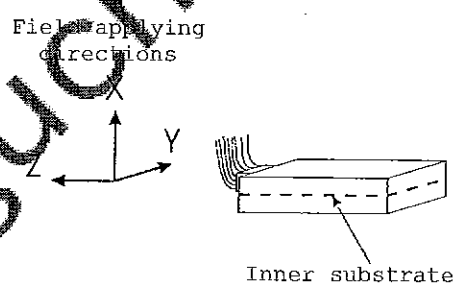


Fig. 18 Specimen Setting Directions

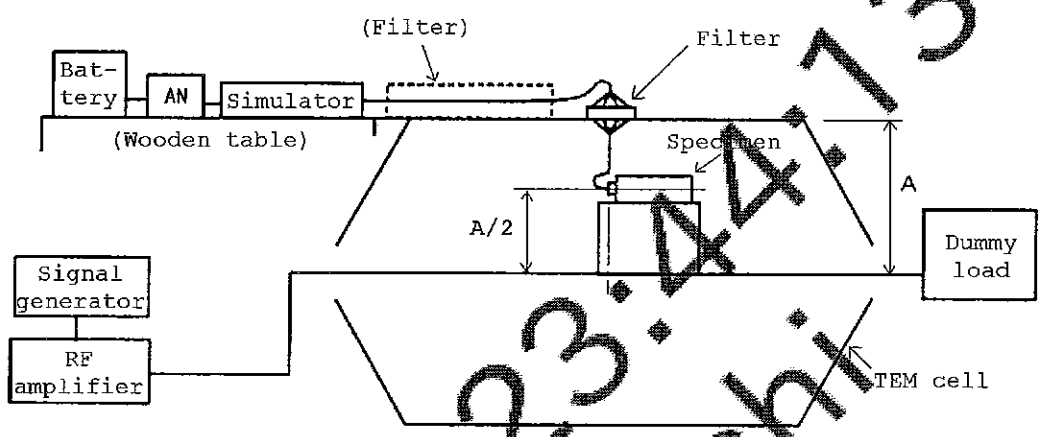


Fig. 19 TEM Cell Test Bench Configuration

Table 16 Test Levels

Test level	Electric field strength (V/m)
Level Ⅰ	200
Level Ⅱ	100
Level Ⅲ	60
Level Ⅳ	30

4.5.2 BCI Test

(1) Setting specimen and test bench

The basic layout of the specimen shall be as shown in Fig. 20.

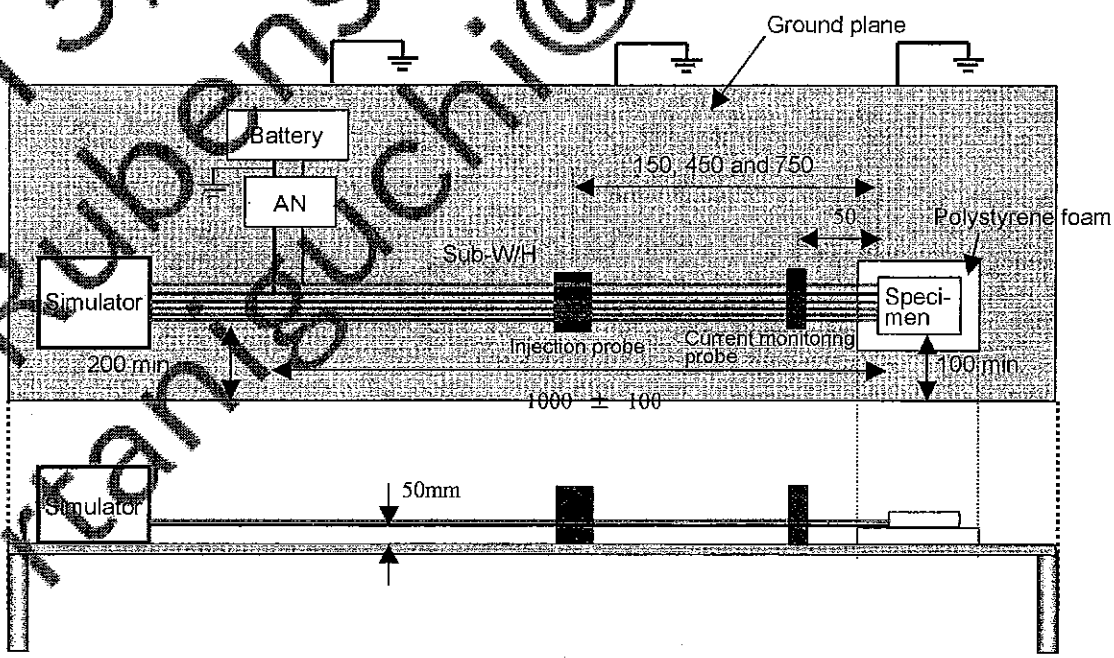


Fig. 20 Test Bench Layout Example for BCI Test (Unit: mm)

Regarding the test bench and current injection position, set them as in the actual vehicle conditions. The implementation example is shown in Fig. 21.

(a) Cable type for sub-W/H
Shielded wire or twisted pair wire that is actually used for an actual vehicle or the equivalent one shall be used.

(b) Length of sub-W/H
The length of sub-W/H shall be as in the actual vehicle regardless of the specification (1000±100 mm) in Fig. 20.

(c) Route of sub-W/H
In the actual vehicle installation condition, if sub-W/H of a specific terminal of the specimen is routed ① near the clearance between the engine hood and the fender or the cowl or ② near the body edge, reinforcement or member, or other place where the electric field tends to concentrate, separate these sub-W/Hs and inject current.

(d) Ground system
Configure the ground system including the case by separating into each ground, and inject current for each. When a part of the specimen is earthed to the vehicle body via metal case or metal bracket, insulate with polyurethane foam and earth to the ground plane by wires (do not directly earth to the ground plane and wires used for grounding shall have minimum length that is just enough to insert injection probe). If earth wire location is different in the actual vehicle, use AN and isolate the wire locations in a radio frequency range.

(e) Signal system
Individually inject current into the open collector circuit not mounted with condenser, the analog current detection and feedback circuit and the analog voltage detection and feedback circuit.

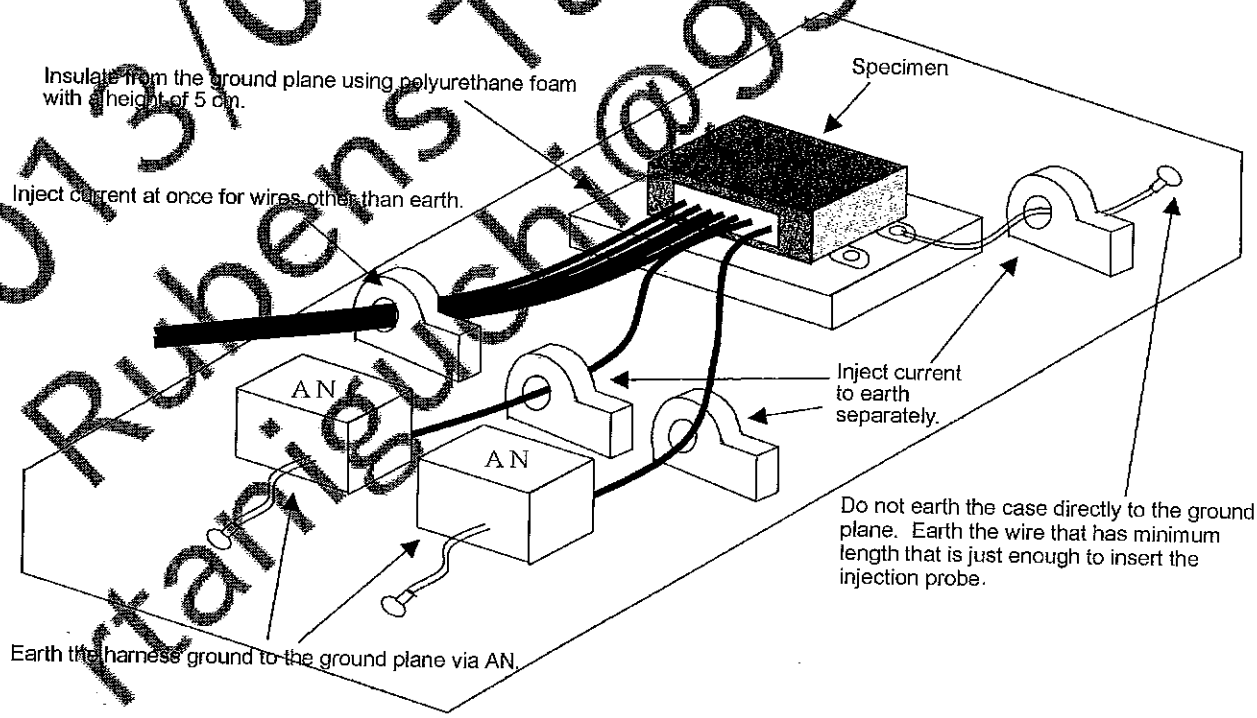


Fig. 21 Implementation Example of BCI Test

(2) Setting of test output

Check the functions as specified in the provisions of the specimen while injecting current to the sub W/H. If there is no special provision for the specimens, select the injection current for each specimen according to the test level as shown in Table 17.

Table 17 Test Level and Injection Current

Test level	Injection current (mA)	
	Injection into multiple terminals at once	Individual injection
Level I	200	160
Level II	100	80
Level III	60	50
Level IV	30	25

(3) Selecting W/H to inject current

In the case where the terminals to inject current and its combination are omitted, based on the concept specified in Table 18, reach agreement with related departments regarding each/lump-sum input and necessary/unnecessary injection and write the result in the test plan.

Table 18 Concept of Reducing Terminals to Inject Current

Characteristics of circuit	Injection method	Prerequisite, reason, side effect	Example of selection in the case of Engine computer	
			Terminal name	Circuit
Same circuit (same impedance)	Lump-sum input	Regarding the lump-sum input to the multiple same circuits (same impedance), current that has the same frequency characteristics as that of the individual input can be induced. However, inflowing current value is smaller than that of the individual input, therefore, calibration of the induced current is required.	IGT1 IGT2 IGT3 IGT4	Open emitter that is output at ignition of each cylinder
			#10 #20 #30 #40	Open collector that is output at injection of each cylinder
Circuit that is strong against noise	Omission of test	Applicable for the cases where bypass circuit for high frequency noise such as bypass condenser is set near the input terminal, electromagnetic interference resistance is judged as marginal.	NTB NTO	Bypass condenser is inserted into input portion of voltage or current signal
Terminal that is less important	Substitute by injecting current to all wires at once	Applicable to the terminals whose functions are ranked "ハ" (ha) to "ヘ" (he). Since the importance level is low, check electromagnetic interference resistance by injecting current to all wires at once.	STA TC WFSE	Switch input of rank "ホ" (ho)

4.5.3 Stripline Test

Set the specimen and sub-W/H at the locations shown in Fig. 22. Select the proper electric field strength from Table 16 in line with each test level specified for the specimen.

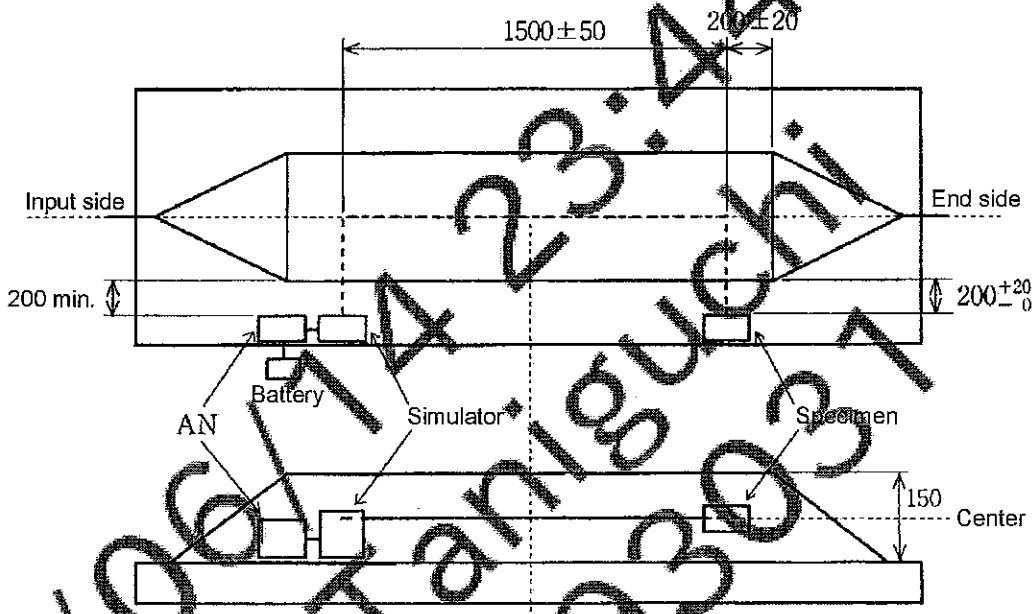


Fig. 22 Test Bench Configuration for Stripline Test (Unit: mm)

4.5.4 Free Field Test

Set the specimen at the location shown in Fig. 23. For specimens whose cases are electrically connected to vehicle body when they are mounted in the vehicle, connect the grounded portion of the specimen case to the ground plane. If metal parts are placed around the specimen when being mounted in the vehicle, place the metal parts to conform to the actual vehicle environment. Select the proper electric field strength from Table 16 in line with each test level specified for the specimen.

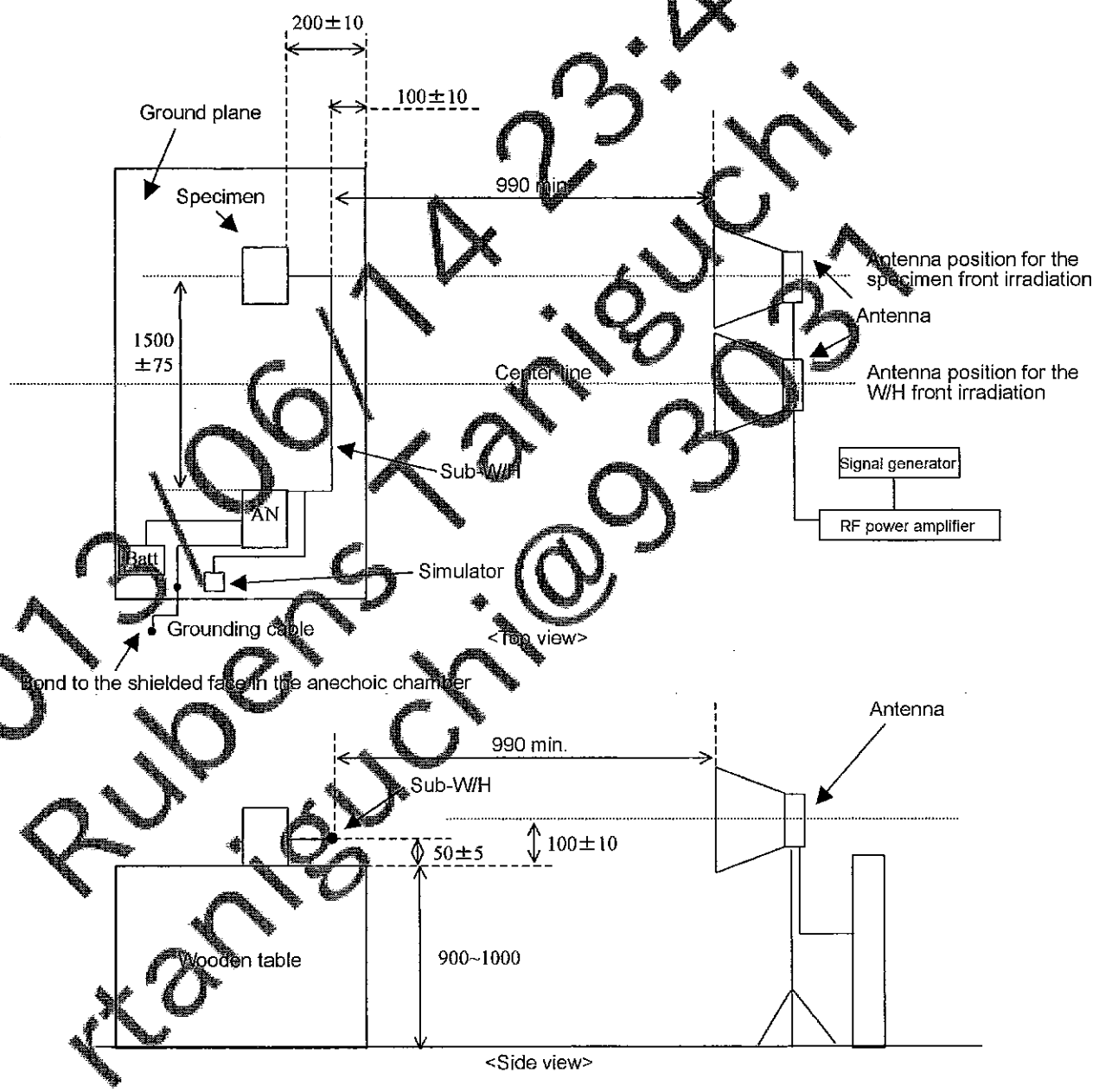


Fig. 23 Configuration of Test Bench for Free Field Test (Unit: mm)

4.5.5 Radio Equipment Antenna Nearby Test

(1) 28 MHz Test

Set the specimen as shown in Fig. 24. Adjust the distance between the specimen center and the antenna the same as the distance between the antenna and electric field probe location specified for the calibration. Select the proper electric field strength from Table 16 in line with each test level specified for the specimen.
This test may be substituted by the test specified in Section 4.5.4.

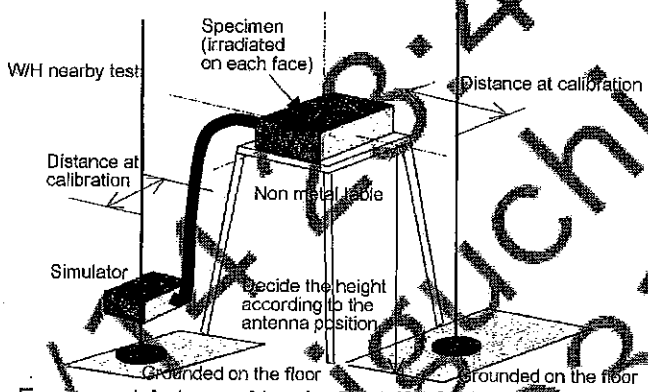


Fig. 24 Layout for Radio Equipment Antenna Nearby Test (28 MHz) (when Ground Plane is Grounded on Floor)

Remark: Locate the specimen so that its center is located at the reference point (the position where the electric field probe is located at calibration).

(2) 50 MHz Test

Set the specimen as shown in Fig. 25. Select an antenna to be used here without specimen based on Table 11 and VSWR shall be 1.5 or less.

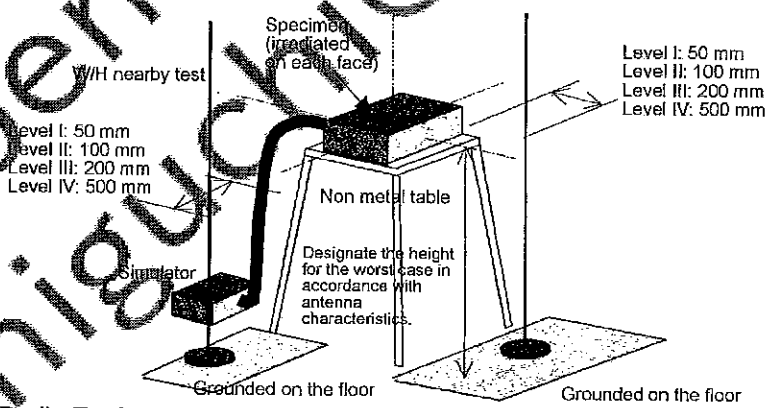


Fig. 25 Layout for Radio Equipment Antenna Nearby Test (50 MHz Test) (when Ground Plane is Grounded on Floor)

Remark: Locate the specimen and sub-W/H to which the antenna is moved closer at a height where the electric field strength and the magnetic field strength are maximized.
In the case where the maximum height of the magnetic field strength becomes the root of the antenna and the setting of the specimen is difficult, height 100 mm may be used as substitute.

Set the antenna input power for test according to Table 19. Compensate for the power loss caused by the coaxial cable from the power meter to the antenna input as calculated in Section 4.4.6 with the equation (4).

$P_T = P \times 10^{L/10}$ (W) ----- (4)

where,
P_T: amplifier forward power (W)
P: output upon test (Table 19)
L: loss by coaxial cable (dB)

Table 19 Test Frequencies, Test Outputs and Test Antennas for Radio Equipment Antenna Nearby Test

Test frequency (MHz)	Test output (W)	Test antenna
50	10	λ/4 mobile antenna

Select the proper nearby distance to the antenna from Table 20 for each test level specified for the specimen.

Table 20 Test Levels and Antenna Nearby Distances

Test level	Antenna nearby distance (cm)
Level I	5
Level II	10
Level III	20
Level IV	50

(3) Tests other than 28 and 50 MHz tests

Set the specimen in conformance to surrounding metal parts (including attaching bracket) and install the W/H in accordance with the actual vehicle installation environment. Figs. 26 to 29 show installation examples. If the actual vehicle installation environment cannot be specified, install as shown in Fig. 30. The antenna to be used here is in the condition without specimen in accordance with Section 4.3 (7)(c) and (d), and select the proper antenna so that the VSWR becomes 1.5 or smaller. If the installation environment of ECU in actual vehicle (W/H length, connection mate and layout) is reproduced, the nearby tests for nearing the part surface where the radio equipment antenna is not likely to come close and for the antenna piercing direction may be omitted. Perform the antenna nearby test for sub-W/H within the 1/2λ range.

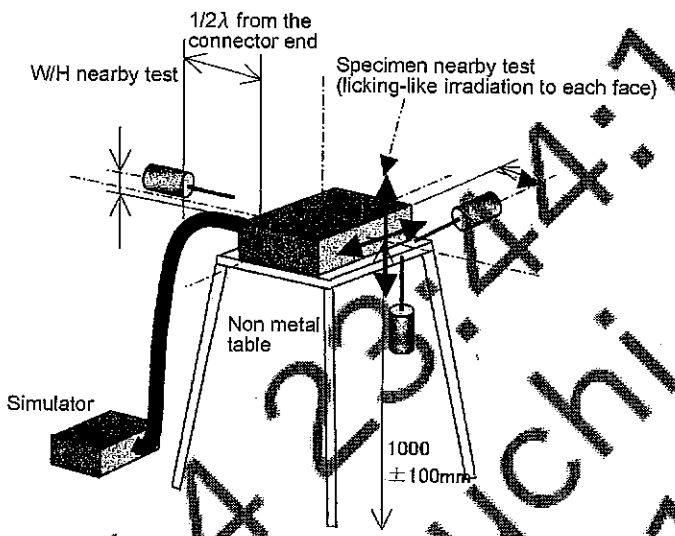


Fig. 26 Layout Example 1 for Radio Equipment Antenna Nearby Test (Other than Test at 28 and 50 MHz) (No Surrounding Metal Parts)

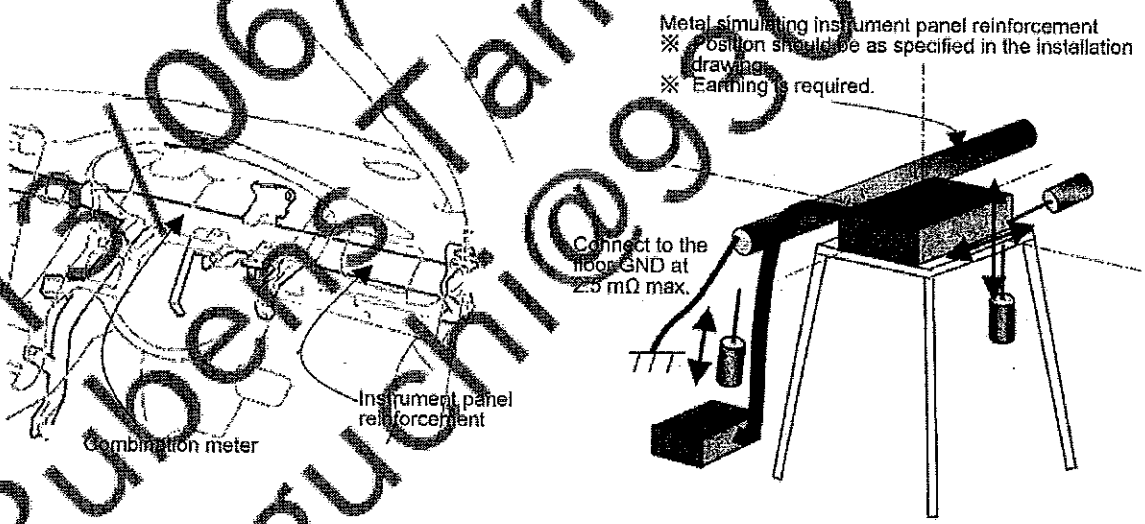


Fig. 27-(a) Actual Vehicle conditions

Fig. 27-(b) Example of bench layout

Fig. 27 Layout Example 2 for Radio Equipment Antenna Nearby Test (Other than Test at 28 and 50 MHz) (Installed in Instrument Metal)

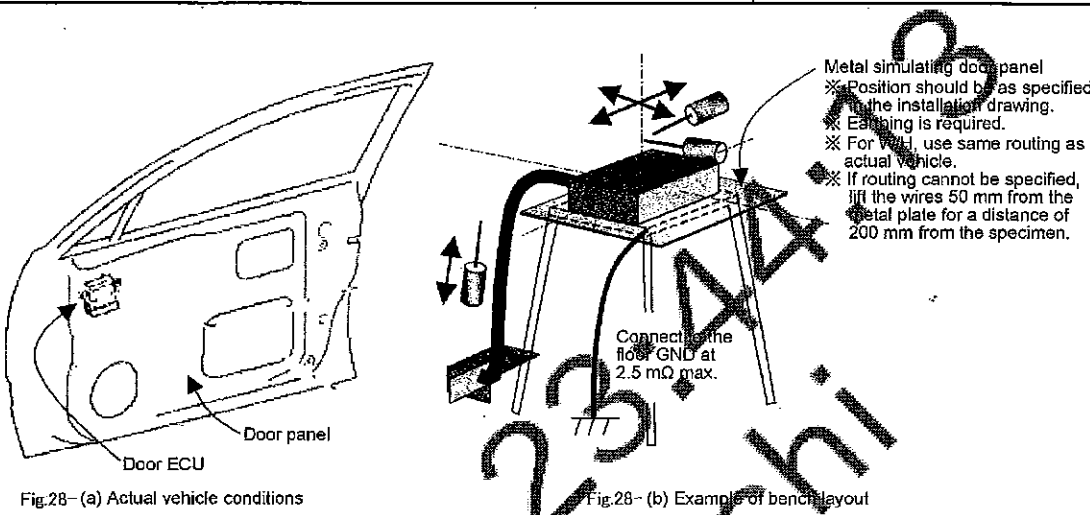


Fig. 28 Layout Example 3 for Radio Equipment Antenna Nearby Test (Other than Test at 28 and 50 MHz) (Installed in Door Panel)

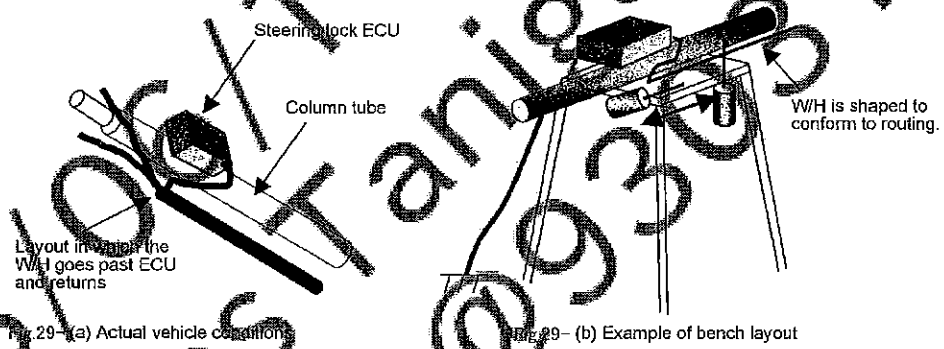


Fig. 29 Layout Example 4 for Radio Equipment Antenna Nearby Test (Other than Test at 28 and 50 MHz) (W/H Layout)

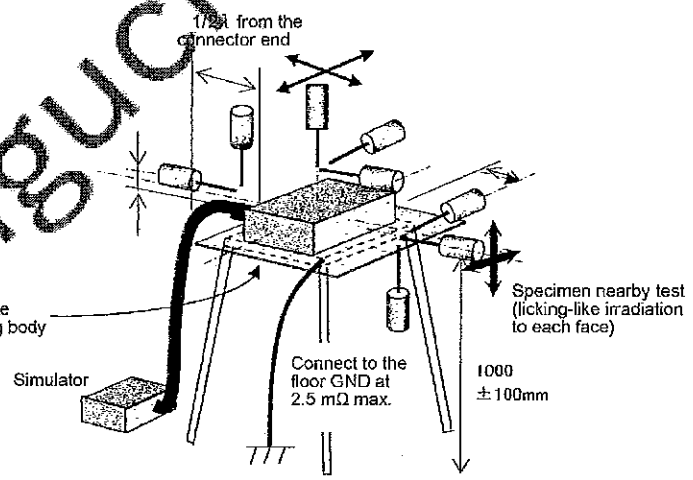


Fig. 30 Layout Example 5 for Radio Equipment Antenna Nearby Test (Other than Test at 28 and 50 MHz) (If Unable to Specify)

In the actual vehicle reproduced condition of test bench, select the antenna input power for test from Table 21, and select the antenna nearby distance from Table 22.
Compensate for the power loss caused by the coaxial cable from the power meter to the antenna input as calculated in Sections 4.4.7 and 4.4.8 with the equation (5).

$P_T = P \times 10^{L/10}$ (W) ----- (5)

where,
P_T: amplifier forward power (W)
P: output upon test (Table 21)
L: loss by coaxial cable (dB)

Table 21 Test Frequencies, Test Outputs and Test Antennas for Radio Equipment Antenna Nearby Test

Test frequency (MHz)	Test output (W)	Test antenna
144	15	λ/4 mono-pole antenna
430	15	λ/4 sleeve antenna
900	10	λ/4 sleeve antenna
1280	2	λ/4 sleeve antenna

Table 22 Test Levels and Antenna Nearby Distances

Test level	Antenna nearby distance (cm)
Level I	5
Level II	10
Level III	20
Level IV	50

Remark: If it is possible that the antenna for handy radio equipment will come closer than the distance listed in Table 22 in the actual vehicle, adjust the antenna nearby distance in the part test to the actual vehicle environment after discussion among the parties concerned.

4.5.6 Mobile Phone Antenna Nearby Test

Set the specimen in conformance to surrounding metal parts (including attaching bracket) and install the W/H in accordance with the actual vehicle installation environment. Figs. 28 to 29 show installation examples. If the actual vehicle installation environment cannot be specified, install as shown in Fig. 30. The antenna to be used here is in the condition without specimen in accordance with Section 4.3 (7)(d), and select the proper antenna so that the VSWR becomes 1.5 or smaller. If the installation environment of ECU in the actual vehicle (W/H length, connection mate and layout) is reproduced, the nearby tests for nearing the surface where the mobile phone antenna is not likely to come close and for the antenna piercing direction may be omitted. Perform the antenna nearby test for sub-W/H within the 1/2 λ range. Set the electromagnetic waves for the test based on Table 23.

Table 23 Test Frequency and Test Signal

Test frequency (MHz)	Applicable destination					
	Japan		North America		Other than those specified on the left	
	CW	PM	CW	PM	CW	PM
835	○	---	○	○	○	○
900	○	○	---	---	○	○
1750	○	---	○	---	○	○
1880	---	○	○	○	○	○

In the actual vehicle reproduced condition on test bench, select the antenna input power for test from Table 24, and select the antenna nearby distance from Table 25.

In order to compensate for the power loss caused by the coaxial cable from the power meter to the antenna input as calculated in Section 4.4.8, check on the loss in advance, and set the forward power of the amplifier in accordance with the method shown in the equation (6).

$$P_T = P \times 10^{L/10} \ (W) \quad \text{------ (6)}$$

where,

P_T: amplifier forward power (W)

P: output upon test (Table 24)

L: loss by coaxial cable (dB)

Table 24 Test Frequencies and Test Outputs

Test frequency (MHz)	Test output (W)		
	When the installation environment of ECU in actual vehicle (W/H length, connection mate and layout) is reproduced	When the actual vehicle environment cannot be specified	Between the two cases on left
835	2	4	2 to 4
900	2	4	2 to 4
1750	2	4	2 to 4
1880	1	2	1 to 2

Table 25 Antenna Nearby Distances

Test level	Antenna nearby distance (cm)		
	When the installation environment of ECU in actual vehicle (W/H length, connection mate and layout) is reproduced	When the actual vehicle environment cannot be specified	Between the two cases on left
Level I	Operation unit and display unit: 0 Other than the above: 2	Operation unit and display unit: 0 Other than the above: 1	Operation unit and display unit: 0 Other than the above: 1
Level II	2	1	1
Level III	5	2	2
Level IV	20	10	10

Remarks:

1. The operation unit and display unit shall be such to allow the contact between the antenna and the specimen as installed on the vehicle.
2. If it is possible that the antenna for mobile phone will come closer than the distance listed in Table 25 in the actual vehicle, adjust the antenna nearby distance in the part test to the actual vehicle environment after discussion among the parties concerned.

Attached Table 1 Operating Conditions/Functional Rank List (Example in the Case of Multimedia)

Mode selection											Criteria
Evaluation mode	Anticipated problems arising from irradiation	Mode dependence	Test operation mode								Rank
			AM	FM	CD	Ripping and HDD	DVD	DTV	VTR	CAN	
Radio (AM)	Unable to receive AM broadcast	AM	O								"ハ" (ha)
	Generation of noise during AM broadcast reception	AM	O								"ロ" (ro)
Radio (FM)	Unable to receive FM broadcast	FM		O							"ハ" (ha)
	Generation of noise during FM broadcast reception	FM		O							"ロ" (ro)
CD	CD inoperable	CD			O						"ハ" (ha)
	Generation of noise during CD play	CD			O						"ロ" (ro)
DVD	DVD inoperable	DVD					O				"ハ" (ha)
	DISC LOAD/EJECT inoperable	DVD									—
	Generation of audio noise during DVD play	DVD					O				"ロ" (ro)
	Fuzzy video during DVD play	DVD									"ハ" (ha)
HDD audio	HDD audio inoperable	HDD audio				O					"ハ" (ha)
	Generation of noise during HDD audio play	HDD audio				O					"ロ" (ro)
	Slow CD ripping	HDD audio				O					"ハ" (ha)
VTR	Video display inoperable on VTR	VTR							O		"ハ" (ha)
	Generation of audio noise during VTR play	VTR							O		"ハ" (ha)
	Fuzzy video during VTR play	VTR							O		"ハ" (ha)
DTV	DTV inoperable	DTV						O			"ハ" (ha)
	DTV screen noise	DTV						O			"ハ" (ha)
	DTV audio noise	DTV									"ロ" (ro)
AUDIO	Volume changes by itself	All modes	O	O	O	O	O	O	O		"ロ" (ro)
	Audio noise	All modes	O	O	O	O	O	O	O		"ロ" (ro)
	Discontinuous sound	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	No sound	All modes	O	O	O	O	O	O	O		"ハ" (ha)
Display control	Picture quality changes by itself	All modes	O	O	O		O	O	O		"ハ" (ha)
	Daytime/Nighttime picture switch activates by itself	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	Black picture	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	White picture	All modes	O	O	O	O	O	O	O		"ハ" (ha)
Directly connected wire interface	SPD inoperable	Navigational system		O	O						"ハ" (ha)
	BU and ACC detection (reset) activates by itself	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	REV inoperable	Back camera			O						"ハ" (ha)
	PKB inoperable	DTV, DVD					O	O			"ハ" (ha)
	Steering switch responds by itself	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	Security horn	Operation by direct connection								O	"イ" (i)
Mechanism operation	FAN inoperable	All modes		O	O	O	O	O	O		"ハ" (ha)
	Mode switching activates by itself	All modes		O	O	O	O	O	O		"ハ" (ha)
NAVI	Fuzzy map display	Navigational system		O							"ハ" (ha)
CAN	No communication blackout diagnosis	CAN								O	"イ" (i)
BGM	Noise in camera image	BGM			O						"ハ" (ha)
	Camera image black picture	BGM			O						"ハ" (ha)
Back camera	Noise in back camera image	Back camera			O						"ハ" (ha)
	Back camera black picture	Back camera			O						"ハ" (ha)
Forgotten memory	Forgotten audio memory	All modes	O	O	O	O	O	O	O		"ロ" (ro)
	Forgotten navigational system memory	All modes	O	O	O	O	O	O	O		"ロ" (ro)
	Reset	All modes	O	O	O	O	O	O	O		"ハ" (ha)
	Program loading	All modes	O	O	O	O	O	O	O		"ハ" (ha)

■ Judgment method for each class

Class	Judgment method
Class A	<<Test electric field>> Check that the specimen functions as designed or within the acceptable range during irradiation and thereafter.
Class B	<<Test electric field>> - Check that there are 2 points or more of audio noise. - Check that the condition of screen noise or no display automatically returns to normal after irradiation. After checking the above, check the malfunctioning phenomenon in the electric field for judgment. <<Electric field for judgment>> - Check that there are 3 points or more of audio noise. - Check that there are 3 points or more of screen noise and that no display/black picture will not occur.
Class C	<<Test electric field>> Check that the condition automatically returns to normal after irradiation, and check the malfunctioning phenomenon in the electric field for judgment. <<Electric field for judgment>> Check that the malfunctioning phenomenon will not occur.

<<Special notes>>
- Perform the test at the test level for each mode, and check the malfunctioning phenomenon in the electric field for judgment specified on left only if any malfunctioning phenomenon has occurred. (See "Judgment method for each class".)
- Clearly indicate the occurrence of any malfunctioning phenomenon in the report even if the conditions for judgment are fulfilled.