INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Subcommittee A: Radio-interference measurements and statistical techniques

Project: CISPR 16-1 Amd.2 f2 Ed.1.0

Subject: Amendment to CISPR 16-1: Clause 5.12, Test sites for measurement of radio disturbance field strength for the frequency range 1 GHz to 18 GHz; Subclause 5.12.2 Validation of the test site

Proposed amendment to CISPR 16-1 text:

Replace the present text of clause 5.12.2 by the following text :

5.12.2 Validation of the test site

A measurement site shall be considered acceptable for radiated electromagnetic field measurements above 1 GHz if the measured horizontal and vertical NSA measurements are within ± 4dB of the theoretical free space attenuation for an ideal site.

The validation is probated only for the combination of site, receiving antenna and absorbing material placed (or not) on the ground. Therefore, measurements to determine equipment compliance according to a product standard shall be made in the same conditions as for the validation procedure. If this is not the case, another validation of the new combination shall be made. If the site is to be used for table-top EUT tests, the table used to accommodate the EUT shall be put in place as an integral part of the combination that is being evaluated. The table on which the EUT is mounted should be a low density dielectric material such as styrofoam or similar material.

The test site shall rely on reflection free conditions (for example an anechoic chamber). If not (for example a semi-anechoic chamber), it may be necessary to use absorbing material on the floor. The smallest recommended area of absorbing material is 1m30 per 1m30 (for a measurement distance of 3m) placed 0.40m ahead of the transmit antenna. This area should be increased if the validation fails, first along the axis between the two antennas and then perpendicular to it.

The test site shall be validated for the used volume of actual EUTs. For that aim, measurements are to be carried out for one center position of the transmitting antenna, for positions 50 cm front and rear of this central position and for positions corresponding to the left and right end sides of the test volume occupied by EUTs (i.e. five measurement positions in total).

In addition, for the measurement at the center position, an additional measurement should be made with the receiving antenna turned 180° with regard to the EUT (i.e. facing the opposite direction). For this center position, a max hold should be made from the measurement facing the EUT and 180° from it and the result of this max hold shall be within the ± 4dB tolerance.

The validation of a test site is performed with two antennas polarized horizontally and vertically with respect to the ground as shown in figures 1 and 2 respectively.

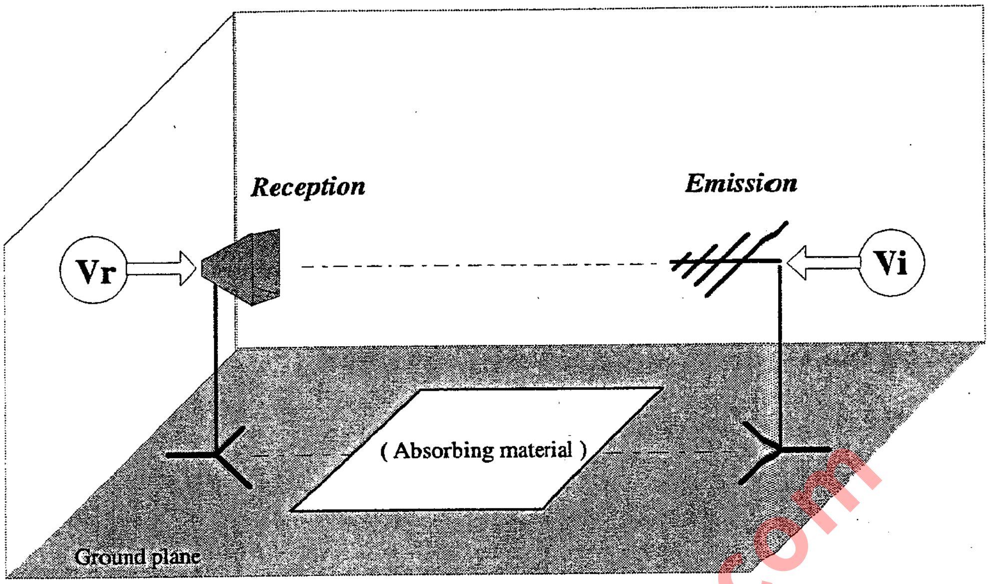


Figure 1 : Horizontal polarisation

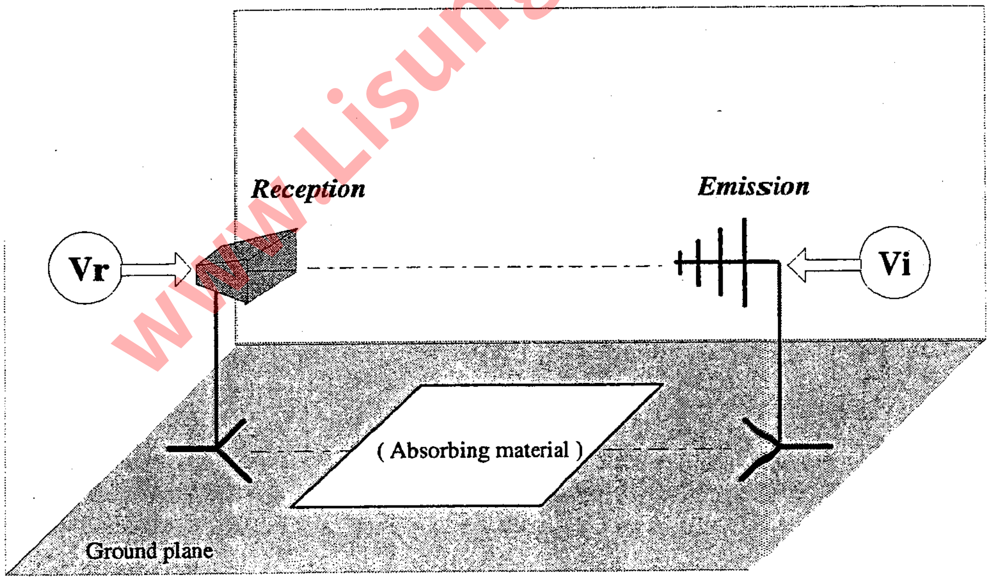


Figure 2 : Vertical Polarisation

5.12.2.1 Validation criteria

The normalised site attenuation (NSA) is expressed in dB. The site is considered suitable when the measured vertical and horizontal NSA's are within ± 4dB of the values given in Section 5.12.2.2. If the ± 4dB criterion is exceeded, the test site must be investigated as described in sections 5.12.2.7.

The deviation between a measured NSA value and the theoretical value shall not be used as a correction for a measured EUT field strength. This procedure shall be used only for validating a test site.

Values given in section 5.12.2.2 shall be used for all types of antennas and for horizontal and vertical polarisation. NSA for frequencies other than those given in the tables should be calculated using the equation given in Section 5.12.2.2.

5.12.2.2 Normalised Site Attenuations (A_N) between 1 and 18 GHz

The theoretical NSA may be calculated from the following equation.

$$A_N(dB) = 20 * \log(R) - 20 * \log(f) + 32 \quad \text{with R in meter and f in MHz}$$

This gives the values in Table 1 (1a and 1b) and Table 2 (2a and 2b) , for a measurement distance of 3m and 1m respectively, where :

R : Horizontal separation distance between the projection of the transmit and receive antennas on the ground plane (in metres).

A_N : normalized site attenuation

Table 1a

Theoretical NSA for frequency from 1 to 10950 MHz

Distance : R = 3 m							
Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)
1000	-18,5	3500	-29,3	6000	-34,0	8500	-37,0
1050	-18,9	3550	-29,5	6050	-34,1	8550	-37,1
1100	-19,3	3600	-29,6	6100	-34,2	8600	-37,1
1150	-19,7	3650	-29,7	6150	-34,2	8650	-37,2
1200	-20,0	3700	-29,8	6200	-34,3	8700	-37,2
1250	-20,4	3750	-29,9	6250	-34,4	8750	-37,3
1300	-20,7	3800	-30,1	6300	-34,4	8800	-37,3
1350	-21,1	3850	-30,2	6350	-34,5	8850	-37,4
1400	-21,4	3900	-30,3	6400	-34,6	8900	-37,4
1450	-21,7	3950	-30,4	6450	-34,6	8950	-37,5
1500	-22,0	4000	-30,5	6500	-34,7	9000	-37,5
1550	-22,3	4050	-30,6	6550	-34,8	9050	-37,6
1600	-22,5	4100	-30,7	6600	-34,8	9100	-37,6
1650	-22,8	4150	-30,8	6650	-34,9	9150	-37,7
1700	-23,1	4200	-30,9	6700	-35,0	9200	-37,7
1750	-23,3	4250	-31,0	6750	-35,0	9250	-37,8
1800	-23,6	4300	-31,1	6800	-35,1	9300	-37,8
1850	-23,8	4350	-31,2	6850	-35,2	9350	-37,9
1900	-24,0	4400	-31,3	6900	-35,2	9400	-37,9
1950	-24,3	4450	-31,4	6950	-35,3	9450	-38,0
2000	-24,5	4500	-31,5	7000	-35,4	9500	-38,0
2050	-24,7	4550	-31,6	7050	-35,4	9550	-38,1
2100	-24,9	4600	-31,7	7100	-35,5	9600	-38,1
2150	-25,1	4650	-31,8	7150	-35,5	9650	-38,1
2200	-25,3	4700	-31,9	7200	-35,6	9700	-38,2
2250	-25,5	4750	-32,0	7250	-35,7	9750	-38,2
2300	-25,7	4800	-32,1	7300	-35,7	9800	-38,3
2350	-25,9	4850	-32,2	7350	-35,8	9850	-38,3
2400	-26,1	4900	-32,3	7400	-35,8	9900	-38,4
2450	-26,2	4950	-32,3	7450	-35,9	9950	-38,4
2500	-26,4	5000	-32,4	7500	-36,0	10000	-38,5
2550	-26,6	5050	-32,5	7550	-36,0	10050	-38,5
2600	-26,8	5100	-32,6	7600	-36,1	10100	-38,5
2650	-26,9	5150	-32,7	7650	-36,1	10150	-38,6
2700	-27,1	5200	-32,8	7700	-36,2	10200	-38,6
2750	-27,2	5250	-32,9	7750	-36,2	10250	-38,7
2800	-27,4	5300	-32,9	7800	-36,3	10300	-38,7
2850	-27,6	5350	-33,0	7850	-36,4	10350	-38,8
2900	-27,7	5400	-33,1	7900	-36,4	10400	-38,8
2950	-27,9	5450	-33,2	7950	-36,5	10450	-38,8
3000	-28,0	5500	-33,3	8000	-36,5	10500	-38,9
3050	-28,1	5550	-33,3	8050	-36,6	10550	-38,9
3100	-28,3	5600	-33,4	8100	-36,6	10600	-39,0
3150	-28,4	5650	-33,5	8150	-36,7	10650	-39,0
3200	-28,6	5700	-33,6	8200	-36,7	10700	-39,0
3250	-28,7	5750	-33,7	8250	-36,8	10750	-39,1
3300	-28,8	5800	-33,7	8300	-36,8	10800	-39,1
3350	-29,0	5850	-33,8	8350	-36,9	10850	-39,2
3400	-29,1	5900	-33,9	8400	-36,9	10900	-39,2
3450	-29,2	5950	-33,9	8450	-37,0	10950	-39,2

Table 2a
Theoretical NSA for frequency from 1 to 10950 MHz

Distance : R = 1 m							
Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)
1000	-28,0	3500	-38,9	6000	-43,6	8500	-46,6
1050	-28,4	3550	-39,0	6050	-43,6	8550	-46,6
1100	-28,8	3600	-39,1	6100	-43,7	8600	-46,7
1150	-29,2	3650	-39,2	6150	-43,8	8650	-46,7
1200	-29,6	3700	-39,4	6200	-43,8	8700	-46,8
1250	-29,9	3750	-39,5	6250	-43,9	8750	-46,8
1300	-30,3	3800	-39,6	6300	-44,0	8800	-46,9
1350	-30,6	3850	-39,7	6350	-44,1	8850	-46,9
1400	-30,9	3900	-39,8	6400	-44,1	8900	-47,0
1450	-31,2	3950	-39,9	6450	-44,2	8950	-47,0
1500	-31,5	4000	-40,0	6500	-44,3	9000	-47,1
1550	-31,8	4050	-40,1	6550	-44,3	9050	-47,1
1600	-32,1	4100	-40,3	6600	-44,4	9100	-47,2
1650	-32,3	4150	-40,4	6650	-44,5	9150	-47,2
1700	-32,6	4200	-40,5	6700	-44,5	9200	-47,3
1750	-32,9	4250	-40,6	6750	-44,6	9250	-47,3
1800	-33,1	4300	-40,7	6800	-44,7	9300	-47,4
1850	-33,3	4350	-40,8	6850	-44,7	9350	-47,4
1900	-33,6	4400	-40,9	6900	-44,8	9400	-47,5
1950	-33,8	4450	-41,0	6950	-44,8	9450	-47,5
2000	-34,0	4500	-41,1	7000	-44,9	9500	-47,6
2050	-34,2	4550	-41,2	7050	-45,0	9550	-47,6
2100	-34,4	4600	-41,3	7100	-45,0	9600	-47,6
2150	-34,6	4650	-41,3	7150	-45,1	9650	-47,7
2200	-34,8	4700	-41,4	7200	-45,1	9700	-47,7
2250	-35,0	4750	-41,5	7250	-45,2	9750	-47,8
2300	-35,2	4800	-41,6	7300	-45,3	9800	-47,8
2350	-35,4	4850	-41,7	7350	-45,3	9850	-47,9
2400	-35,6	4900	-41,8	7400	-45,4	9900	-47,9
2450	-35,8	4950	-41,9	7450	-45,4	9950	-48,0
2500	-36,0	5000	-42,0	7500	-45,5	10000	-48,0
2550	-36,1	5050	-42,1	7550	-45,6	10050	-48,0
2600	-36,3	5100	-42,2	7600	-45,6	10100	-48,1
2650	-36,5	5150	-42,2	7650	-45,7	10150	-48,1
2700	-36,6	5200	-42,3	7700	-45,7	10200	-48,2
2750	-36,8	5250	-42,4	7750	-45,8	10250	-48,2
2800	-36,9	5300	-42,5	7800	-45,8	10300	-48,3
2850	-37,1	5350	-42,6	7850	-45,9	10350	-48,3
2900	-37,2	5400	-42,6	7900	-46,0	10400	-48,3
2950	-37,4	5450	-42,7	7950	-46,0	10450	-48,4
3000	-37,5	5500	-42,8	8000	-46,1	10500	-48,4
3050	-37,7	5550	-42,9	8050	-46,1	10550	-48,5
3100	-37,8	5600	-43,0	8100	-46,2	10600	-48,5
3150	-38,0	5650	-43,0	8150	-46,2	10650	-48,5
3200	-38,1	5700	-43,1	8200	-46,3	10700	-48,6
3250	-38,2	5750	-43,2	8250	-46,3	10750	-48,6
3300	-38,4	5800	-43,3	8300	-46,4	10800	-48,7
3350	-38,5	5850	-43,3	8350	-46,4	10850	-48,7
3400	-38,6	5900	-43,4	8400	-46,5	10900	-48,7
3450	-38,8	5950	-43,5	8450	-46,5	10950	-48,8

Table 2b
Theoretical NSA for frequency from 11000 to 18000 MHz

Distance : R = 1 m							
Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)	Freq. (MHz)	A_N (dB)
11000	-48,8	13000	-50,3	15000	-51,5	17000	-52,6
11050	-48,9	13050	-50,3	15050	-51,6	17050	-52,6
11100	-48,9	13100	-50,3	15100	-51,6	17100	-52,7
11150	-48,9	13150	-50,4	15150	-51,6	17150	-52,7
11200	-49,0	13200	-50,4	15200	-51,6	17200	-52,7
11250	-49,0	13250	-50,4	15250	-51,7	17250	-52,7
11300	-49,1	13300	-50,5	15300	-51,7	17300	-52,8
11350	-49,1	13350	-50,5	15350	-51,7	17350	-52,8
11400	-49,1	13400	-50,5	15400	-51,8	17400	-52,8
11450	-49,2	13450	-50,6	15450	-51,8	17450	-52,8
11500	-49,2	13500	-50,6	15500	-51,8	17500	-52,9
11550	-49,3	13550	-50,6	15550	-51,8	17550	-52,9
11600	-49,3	13600	-50,7	15600	-51,9	17600	-52,9
11650	-49,3	13650	-50,7	15650	-51,9	17650	-52,9
11700	-49,4	13700	-50,7	15700	-51,9	17700	-53,0
11750	-49,4	13750	-50,8	15750	-51,9	17750	-53,0
11800	-49,4	13800	-50,8	15800	-52,0	17800	-53,0
11850	-49,5	13850	-50,8	15850	-52,0	17850	-53,0
11900	-49,5	13900	-50,9	15900	-52,0	17900	-53,1
11950	-49,5	13950	-50,9	15950	-52,1	17950	-53,1
12000	-49,6	14000	-50,9	16000	-52,1	18000	-53,1
12050	-49,6	14050	-51,0	16050	-52,1		
12100	-49,7	14100	-51,0	16100	-52,1		
12150	-49,7	14150	-51,0	16150	-52,2		
12200	-49,7	14200	-51,0	16200	-52,2		
12250	-49,8	14250	-51,1	16250	-52,2		
12300	-49,8	14300	-51,1	16300	-52,2		
12350	-49,8	14350	-51,1	16350	-52,3		
12400	-49,9	14400	-51,2	16400	-52,3		
12450	-49,9	14450	-51,2	16450	-52,3		
12500	-49,9	14500	-51,2	16500	-52,3		
12550	-50,0	14550	-51,3	16550	-52,4		
12600	-50,0	14600	-51,3	16600	-52,4		
12650	-50,0	14650	-51,3	16650	-52,4		
12700	-50,1	14700	-51,3	16700	-52,5		
12750	-50,1	14750	-51,4	16750	-52,5		
12800	-50,1	14800	-51,4	16800	-52,5		
12850	-50,2	14850	-51,4	16850	-52,5		
12900	-50,2	14900	-51,5	16900	-52,6		
12950	-50,2	14950	-51,5	16950	-52,6		

5.12.2.3 General NSA measurement

The transmit antenna shall be an antenna of low directivity, i.e. a log-periodic or dipole antenna but not a horn antenna, in order to be as close as possible to EUT measurement conditions. Linearly polarised antennas are required.

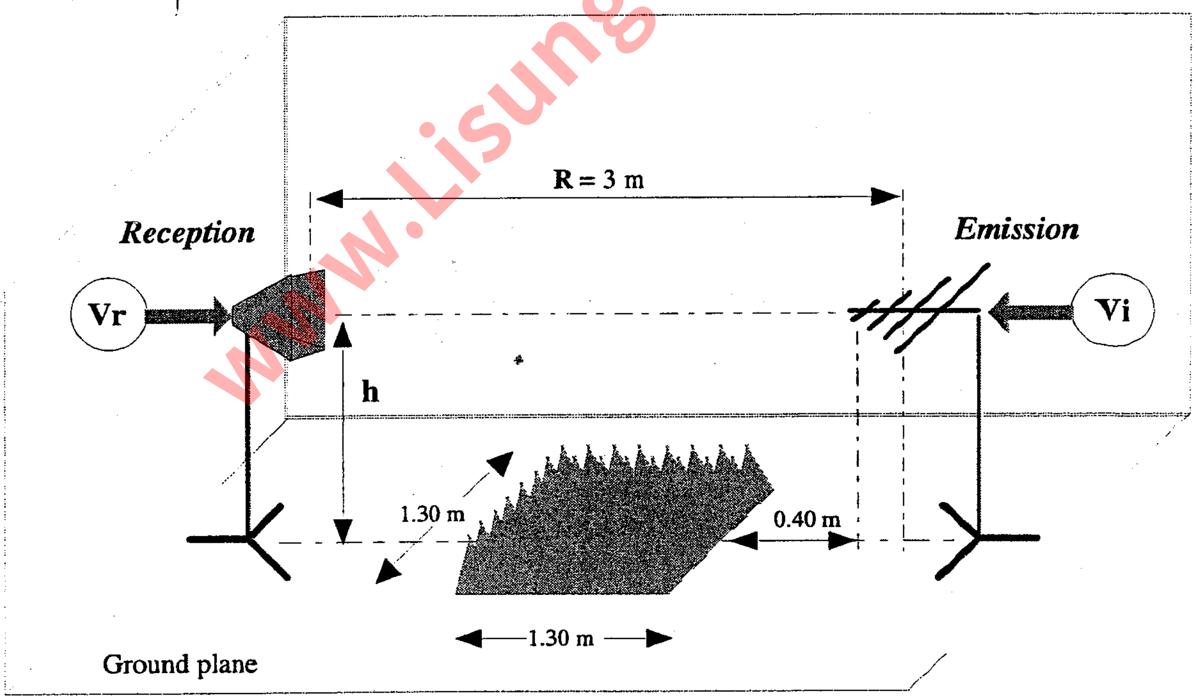
Note 1 – an antenna is considered to have a low directivity if the 3 dB beamwidth of this antenna is wider than 40°.

No height scan in the receive antenna is necessary. Both antennas, transmit and receive, shall be at the same height h.

In order for the configuration to be valid for EUT measurements involving a height scan (applicable when the EUT is larger than the antenna beamwidth), validation measurements shall be performed every 0.50m (for a measurement distance of 3m) between the lowest and the highest antenna heights to be used (e.g. to measure EUTs between 1m and 3m, validation measurements should be done at 1, 1.5, 2, 2.5 and 3m heights). does the transmitting move accordingly? Yes, see figure 4.

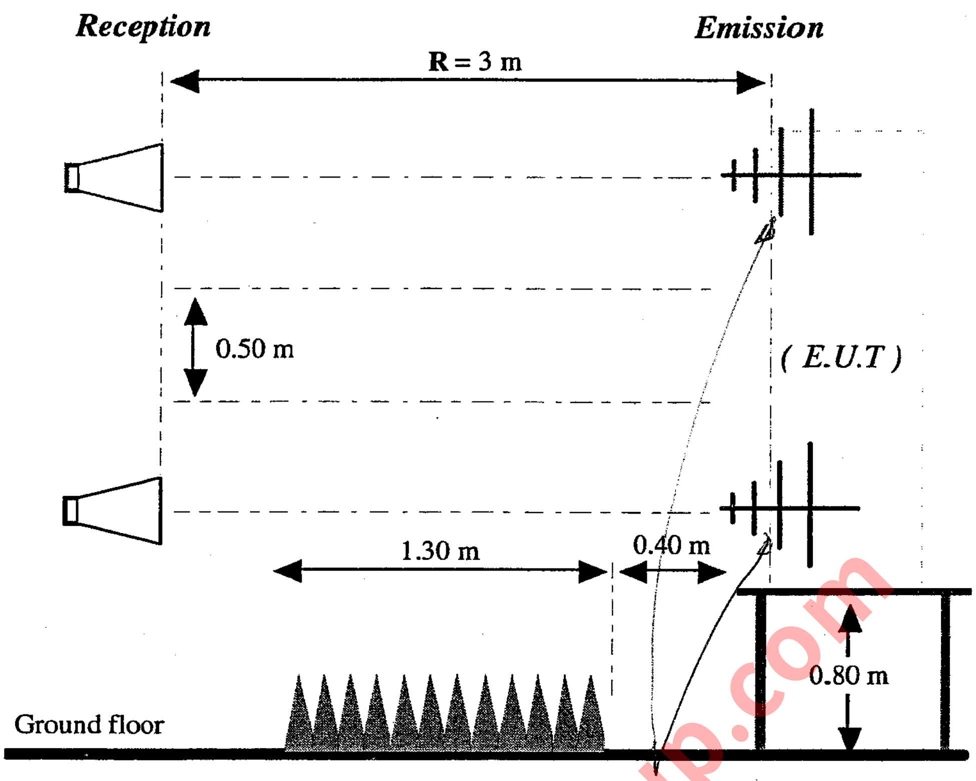
The measurement distance (**R**) shall be 3m between the reference points of the two antennas. However, if the relevant product standard allows for measurements at a closer distance (for example to eliminate the stray reflections or to increase the received signal in a noisy environment), additional site validation measurements may be performed at 1m too. In such a case, the previous recommendations are still valid; except for the height scan which should be done in 0.25m increments. For a measurement distance of 1m, absorbing material may not be necessary. So the validation should be done with absorbing material only if it is necessary.

Figures 3 and 4 below illustrate the NSA measurement procedure for a 3m distance.



R is the measurement distance between the reference points of the antennas

Figure 3 : Site configuration for NSA measurement



R is the measurement distance between the reference points of the antennas

Figure 4 : Height scan

It is recommended that horizontal NSA measurements be performed first. Such measurements are more sensitive to unwanted reflections from the ground than those in vertical polarisation. The site is acceptable if the measured NSA is within ± 4dB of the values given in Table 1 or Table 2 in clause 5.12.2.2. If not, the measurement techniques, instrumentation drift and antenna factor calibration should be checked again. If the ± 4dB criterion is still exceeded, the validation should be done again increasing the area of absorbing materials.

If the ± 4dB criterion is still exceeded, a significant site anomaly is present and corrective action should be taken before proceeding with the vertical polarisation NSA measurement.

For each polarisation, the NSA procedure requires two different measurements of Vr which is the voltage received. The first reading of Vr is with the two coaxial cables disconnected from the two antennas and connected to each other via an adapter. The second reading of Vr is taken with the coaxial cables reconnected to their respective antennas at the same height. For both of these measurements, the signal source voltage, Vi, is kept constant. The first reading of Vr is called V_{DIRECT} and the second is V_{SITE}. These are used in the following equation (1) for the measured NSA, A_N ; all terms are expressed in dB.

$$A_N = V_{DIRECT} - V_{SITE} - AF_T - AF_R \quad (1)$$

where: AF_T is the transmit antenna factor
AF_R is the receive antenna factor

To accomplish these NSA measurements, two techniques can be used, depending on the instrumentation available and on the type of antennas used. Both methods give essentially the same results if correctly applied.

5.12.2.4 Discrete frequency method

With this method, the values of V_{DIRECT} and V_{SITE} shall be recorded at each specific frequency step given in the tables of section 5.12.2.2 one after the other, and then inserted in equation (1) to obtain the measured NSA. To prevent from omission of undesirable reflection effect from the ground floor, the frequency step shall not be greater than 50 MHz.

5.12.2.4.1 Measurement set-up

The signal generator is connected to the transmit antenna with an appropriate length of cable. The transmit antenna is placed at the height h and the desired polarisation is selected.
The receive antenna is placed at the same height h. It is placed at a distance R (= 1 m or 3 m between the reference points of the antennas) from the transmit antenna and it is connected to the measuring receiver or spectrum analyzer via a suitable length of cable. The same polarisation as that for the transmit antenna is selected.

5.12.2.4.2 Measurement procedure

The following steps should be used for each frequency indicated in NSA tables. The measurements are first made for antennas horizontally aligned and then for antennas vertically aligned, both antennas set at the lowest height h necessary.

1) Adjust the output of the signal generator to give a received voltage display well above ambient and measuring receiver or spectrum analyzer noise.
2) Record the signal level. This value is V_{SITE} in equation (1).
3) Disconnect the transmit and receive cables from the antennas. Directly connect these cables with a straight through adapter.
4) Record the signal level with the transmit and receive cables connected together. This value is V_{DIRECT} in equation (1).
5) At each frequency and for each polarisation, enter the values obtained in step 2 and 4 in equation (1).
6) Insert the transmit and receive antenna factors at the measurement frequency as shown in equation (1)
7) Solve equation (1) for A_N which is the NSA for the measurement frequency and the polarisation used.
8) Subtract the value obtained in step 7 from the appropriate NSA contained in tables.
9) If the result in step 8 is less than ± 4dB, the site is considered validated at that frequency, polarization, measurement distance R and absorbing materials configuration.
10) Repeat steps 1 to 9 for the next frequency and polarisation.
11) Repeat step 1 to 10 as many times as necessary in accordance with Clause 5.12.2.3.

If the site fails to satisfy the ± 4dB criterion, Clause 5.12.2.7 suggests possible corrective actions.

5.12.2.5 Swept frequency method

With this method, measurements may be made using automatic measuring equipment having a tracking generator. In this method both antennas are also at the same fixed height and the frequency sweep shall be done over the whole range.

5.12.2.5.1 Measurement set-up

The set-up is similar to section 5.12.2.4.1 method except that only broadband antennas can be used.

5.12.2.5.2 Measurement procedure

The following steps should be made using automatic measuring equipment having a tracking generator. In this method, a frequency scan is performed, with antennas horizontally then vertically aligned, both antennas set at the lowest height h necessary.

1) Adjust the output of the tracking generator to give a received voltage display well above ambient and scanning receiver or spectrum analyzer noise.
2) Set the spectrum analyzer to sweep the desired frequency range. Ensure that the spectrum analyzer is adjusted so that the amplitude of the signal can be displayed over the whole frequency range.
3) Store or record the received voltage display Vr in dB(μV).
4) Disconnect the transmit and receive cables from the antennas. Directly connect these cables with a straight through adapter. Store or record the resulting voltage display.
5) At each frequency, subtract the voltage measured at step 3 from the voltage measured at step 4. Also subtract the antenna factors of the transmit and receive antennas AF_T (dB/m) and AF_R

(dB/m), respectively (antenna factors as a continuous function of frequency may be obtained by using simple linear curve fitting on a set of discrete antenna factor values). The result is the measured NSA over the range of frequencies used, which should be plotted and compared to the theoretical NSA for an ideal site.

6) The differences found between the theoretical NSA and the measured NSA shall fall within the ± 4dB criterion.
7) Repeat step 1 to 6 as many times as necessary in accordance with Clause 5.12.2.3

If the site fails to satisfy the ± 4dB criterion, Clause 5.12.2.7 suggests possible corrective actions.

5.12.2.6 Antenna factor determination

Accurate free-space antenna factors are necessary in measuring NSA. In general, antenna factors provided with the antenna may be inadequate unless they are specifically or individually measured.

5.12.2.7 Site attenuation deviations

If measurements of NSA deviate by more than ± 4dB, several items should be re-checked first:

a) Measurement procedure
b) Accuracy of antenna factors
c) Drift in signal source and accuracy of receiver or spectrum analyzer input attenuator and reading
d) Cables and connections used, they should be specified for these frequencies

If no errors are found, it is necessary to increase the area of absorbing materials first along the axis between the two antennas, and then perpendicular to it.
If the criterion of ± 4dB is still not satisfied then the test site is at fault.