



(51) International Patent Classification:
H04W 8/00 (2009.01) *H04B 17/00* (2006.01)

(21) International Application Number:
PCT/EP2009/063607

(22) International Filing Date:
16 October 2009 (16.10.2009)

(25) Filing Language: English

(26) Publication Language: English

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: IDENTIFYING A DEVICE

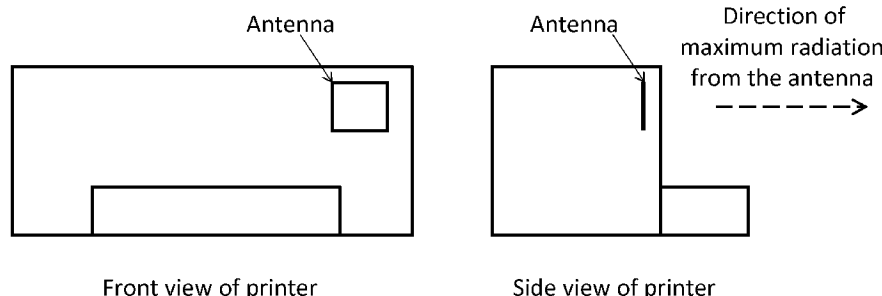


Figure 8

(57) Abstract: A method for identifying a wireless-network-enabled device in an environment comprising a plurality of such devices, the method comprising operating a processor of a receiver device to perform operations comprising for each wireless-network-enabled device within range of the receiver device, receiving a plurality of transmitted signals each positioned around a respective central frequency of transmission for the wireless-network-enabled device in question, determining an average measure for the received signal strength at the receiver device for respective ones of the wireless-network-enabled devices using the signal strengths determined from respective ones of the plurality of received signals, and using the average measure to determine the nearest wireless-network-enabled device to the receiver device.

IDENTIFYING A DEVICE

BACKGROUND

[0001] Identifying and connecting to a nearby, desired, wireless-enabled device is a continuing and frequently difficult problem for the user. It often requires user intervention to manually identify and select the device to which the user wants to connect. Various techniques to aid this process have been explored, such as using a near-touch process using near-field communication techniques for example. However, these techniques generally rely on some out-of-band method for choosing a target device, and consequently add cost and complexity to an existing system.

[0002] In addition to out-of-band methods, infrastructure-based techniques have been proposed for indoor-positioning of devices. When connected to such a system it may be possible to determine the nearest device. However, these types of systems require the installation and commissioning of expensive infrastructure, and are not capable of being used in an ad-hoc fashion as would be important for consumer applications for example.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] Various features and advantages of the present disclosure will be apparent from the detailed description which follows, taken in conjunction with the accompanying drawings, which together illustrate, by way of example only, features of the present disclosure, and wherein:

[0004] Figure 1a is a schematic representation of a transmitter and receiver positioned a distance d from one another;

[0005] Figure 1b is a graph depicting how K-factor varies with distance d for the scenario depicted in figure 1a;

[0006] Figure 2a is a graph showing Rician fading bounds for a laboratory environment;

[0007] Figure 2b is a graph showing Rician fading bounds for a domestic environment;

[0008] Figure 3 is a schematic representation of a model for a complex scenario with multiple reflectors;

[0009] Figure 4 is a graph depicting 99% fading bounds for analytic and Monte-Carlo Rician fading for the scenario depicted in figure 3;

[00010] Figure 5 is a graph depicting the probability contours for 1 and 75 frequency sample simulations;

[00011] Figure 6 is a graph depicting the probability of correct detection for various numbers of frequency samples, with a desired device 1.5m from a receiver;

[00012] Figure 7 is a graph showing 99% contours for devices with different transmit powers; and

[00013] Figure 8 is a schematic representation of the positioning of a directional antenna within the body of a printer.

DETAILED DESCRIPTION

[00014] Line of sight propagation from a transmitter can be modeled using the Rician fading model which can be described using:

$$p(x) = \frac{2x(K+1)}{\Omega_p} \exp\left\{-K - \frac{(K+1)x^2}{\Omega_p}\right\} I_0\left(2x\sqrt{\frac{K(K+1)}{\Omega_p}}\right)$$

where Ω_p = average power, I_0 is a modified Bessel function of the first kind, and K = the Rician K-factor which is the ratio of the power of the line-of-sight and reflected components arriving at a receiver. When K = 0, the distribution becomes equivalent to the Rayleigh distribution.

[00015] When very short ranges and a strong line-of sight component are likely, such as an indoor environment for example, the K-factor can vary significantly over relatively small distances. Figure 1a is a schematic representation of a transmitter and receiver positioned a distance d from one another. A reflecting surface is positioned such that it reflects a portion of the signal transmitted from the transmitter, resulting in an additional signal received at the receiver. If the distance d is varied then a K-factor as shown in figure 1b is obtained.

[00016] Figure 1b is a graph depicting how K-factor varies with distance d for the scenario depicted in figure 1a. Two environments are i) a home environment, i.e. a typical domestic environment constructed of timber and brick with only sparsely located metallic items such as radiators and consumer electronic equipment, and ii) a laboratory environment comprising test equipment with largely metallic suspended floors and ceilings. For the graph of figure 1b, a reflection coefficient of 0.7 is used to the laboratory environment, and 0.4 for the domestic environment.

[00017] Using these values results in a variation in propagation loss over distance at a frequency of 2.4GHz as depicted in figures 2a and 2b. Figure 2a is a graph showing Rician fading bounds for a laboratory environment as described above. Figure 2b is a graph showing Rician fading bounds for a domestic environment as described above.

[00018] So, for example, for a device positioned 0.5m from a measurement point in a domestic environment it is possible to experience a maximum propagation loss of 38dB in 99% of cases. It is also possible for there to be a minimum loss at 1.4m. Therefore, in order to ensure that when the nearest

device is located 0.5m from the power measurement point and it exhibits the highest power in 99% of cases, then any other similar device must be at least $1.4 - 0.5 = 0.9\text{m}$ beyond that nearest device.

[00019] According to an embodiment, systems in which frequency hopping is used, such as Bluetooth systems for example, can yield a better discrimination between devices based on average signal strength. Figure 3 is a schematic representation of a model for a complex scenario in which there are multiple reflectors which are randomly positioned within a defined space. According to an embodiment, a Monte-Carlo simulation can be performed using the scenario of figure 3. For each Monte-Carlo trial, n reflected rays are randomly placed within the defined space, each reflector having a reflection coefficient between zero and an upper limit.

[00020] This approach yields a propagation characteristic that is very similar to the analytical solution for the distance-dependant K-factor Rician distribution given earlier. Figure 4 illustrates this result, showing good agreement between a single-frequency 1000-trial simulation and the analytic solution.

[00021] Using this approach, the probability of correctly identifying the nearest device has been computed for a variety of device separations, and over a number of frequency samples. Figure 5 shows these results as contours of probability for a range of wanted and unwanted device distances and with averaging over 75 frequency samples spaced 1MHz apart. Also shown is the result of using only one frequency sample.

[00022] Figure 5 shows the benefit of averaging signal strength over a number of frequencies. The distance that the unwanted device must be beyond the wanted device reduces by nearly 50% when averaging over 75 frequencies for example. This dependence on frequency sample averaging is better illustrated in Figure 6, which shows the effect on the probability of correctly identifying the

nearest device, located in this example at 1.5m from the receiver, when changing the number of frequency samples; when increasing from one to five frequency samples the rate of failing to detect the nearest device is decreased by 70%, with little benefit to be gained from using more than five frequency samples.

[00023] According to an embodiment, it is therefore possible to identify and connect to a nearby, desired, wireless-enabled device by determining an average signal strength over a number of frequency channels centred around the central frequency of communication for the devices in question. With, for example, a frequency-hopping system, such as Bluetooth, the nearby desired wireless-enabled device will communicate over a sequence of frequency channels as required by the system's air-interface protocol specification. Thus after communication has been underway for a time that requires the requisite minimum number of frequency channels to be used, as described above, an average power estimation can be made using power measurement data recorded during the communication on each of the channels used.

[00024] According to an embodiment, a device can therefore determine the nearest wireless network enabled to it by measure the average received signal strength the over a range of frequencies. Thus in a practical case at 2.4GHz for a Bluetooth frequency hopping system for example, the device can measure the received power at at-least 5 separate frequencies spaced across the 2.4-2.483GHz band, and average the measurement. This will reduce the rate of incorrect detection of the nearest device by up to 70%. A receiver of the device can also implement a received-power threshold above which devices must be detected for the nearest-device detection algorithm to operate. This will ensure that reliability of detection is maintained at a sufficiently high level so as not to cause false triggers and hence degrade the user experience.

[00025] Other WLAN systems that do not use a frequency-hopping scheme do however typically specify communication over pre-defined frequency channels.

For example 802.11 specifies (in North America for example) 11 frequency channels spaced across the 2.4GHz band. Thus, when using an 802.11 system, use can be made of the air-interface protocol's ability to request use of specific channels, and thus measurements of received power over a number of channels can be made, and then an average calculated.

[00026] The preceding description has assumed identical transmit powers for the wanted and unwanted devices. This is unlikely to be the case in practice and thus it is useful to know how any variation in relative transmit power between the devices may affect these results. Figure 7 shows 99% contours for devices with equal power, with the unwanted device 2dB greater, and with the wanted device 4dB greater. These results use averaging over 10 frequency samples.

[00027] It is clear that even several dBs of advantage for the wanted device relative to the unwanted device has a significant affect on the ability to differentiate devices based on signal strength alone. Thus in usage scenarios where pointing towards the front of a device is the most likely mode of use, then using an antenna with a small amount of directional gain will give a significant improvement in a users ability to automatically select the nearest device based on signal strength alone.

[00028] According to an embodiment, a wireless network enabled device to be discovered can therefore have some directionality added to its wireless transmitting antenna, such that there will be a small amount of directionality to the signal transmitted by the wanted device. There are many types of antenna that provide directionality of the degree desired, and typical of these is the patch antenna such as described by Ramesh et al (Design formula for inset fed microstrip patch antenna, Ramesh, M.; Yip, K.B., Journal of Microwaves and Optoelectronics (2003), pp5-10, the contents of which are incorporated herein by reference in their entirety). Such an antenna may be placed in the front facing part of the wireless network enabled device as shown in Figure 8. It may

also be placed in any other part of the wireless network enabled device such that the radiation from the antenna is predominantly greater out the front of the device than out of the rear, sides, top or bottom of the device.

[00029] Consider a typical scenario for example, in which a Bluetooth printer is placed adjacent to a wall. Its front-panel will invariably be facing into the room, and usually towards the user. In this scenario, having the printer's antenna directional to a small degree, such as +4dB gain for example (which can be done with a simple printed, planar, patch antenna for example), out from the front of the printer toward the user, will mean its signal strength when compared with a similar device, perhaps on the other side of the wall, will be sufficiently larger for there to be an accurate differentiation between printers.

[00030] Note that the directional nature of the antenna will not substantially affect the longer-range performance of the printer since propagation in this case is largely non-line-of-sight, and subject to Raleigh fading, and as such directionality of the antenna will not be so important.

[00031] It is to be understood that the above-referenced arrangements are illustrative of the application of the principles disclosed herein. It will be apparent to those of ordinary skill in the art that numerous modifications can be made without departing from the principles and concepts of this disclosure, as set forth in the claims below.

CLAIMS

What is claimed is:

1. A method for identifying a wireless-network-enabled device in an environment comprising a plurality of such devices, the method comprising operating a processor of a receiver device to perform operations comprising:

for each wireless-network-enabled device within range of the receiver device, receiving a plurality of transmitted signals each positioned around a respective central frequency of transmission for the wireless-network-enabled device in question;

determining an average measure for the received signal strength at the receiver device for respective ones of the wireless-network-enabled devices using the signal strengths determined from respective ones of the plurality of received signals; and

using the average measure to determine the nearest wireless-network-enabled device to the receiver device.

2. A method as claimed in claim 1, further comprising:

using a received-power threshold value of the receiver device in order to discriminate between certain ones of the wireless-network-enabled devices.

3. A method as claimed in claim 2, wherein an average measure for the received signal strength for a given wireless-network-enabled device is not determined if one or more of the plurality of transmitted signals received by the receiver device for that wireless-network-enabled device are below the received-power threshold value.

4. A method as claimed in claim 1, comprising receiving at least two transmitted signals each positioned around a respective central frequency of transmission for a wireless-network-enabled device.

5. A method as claimed in claim 1, wherein at least one of the wireless-network-enabled devices comprises an antenna with directional gain.

6. A receiver device for identifying a wireless-network-enabled device in an environment comprising a plurality of such devices, comprising:

- a computer-readable medium storing computer-readable instructions; and a data processor coupled to the computer-readable medium, operable to execute the instructions, and based at least in part on the execution of the instructions operable to perform operations comprising:

- for each wireless-network-enabled device within range of the receiver device, receiving a plurality of transmitted signals each centered around a respective central frequency of transmission for the wireless-network-enabled device in question;

- determining an average measure for the received signal strength at the receiver device for respective ones of the wireless-network-enabled devices using the signal strengths determined from respective ones of the plurality of received signals; and

- using the average measure to determine the nearest wireless-network-enabled device to the receiver device.

7. A receiver device as claimed in claim 6, further operable to:

- use a received-power threshold value in order to discriminate between certain ones of the wireless-network-enabled devices.

8. A receiver device as claimed in claim 7, further operable to discriminate between respective ones of the wireless-network-enabled devices if one or more of the plurality of transmitted signals received by the receiver device for that wireless-network-enabled device is below the received-power threshold value.

9. A method for communicating with a wireless-network-device, the device comprising an antenna with directional gain, the method comprising:

receiving a set of signals from first and second wireless-network-enabled devices;

determining a measure for the signal strength of respective ones of the received signals in the set for the first and second devices;

generating respective measures for the average received signal strength from the first and second devices; and

on the basis of the generated measures selecting a device from the first and second devices for communication.

10. A method as claimed in claim 9, wherein the set of signals comprises at least two signals transmitted from each of the first and second devices.

11. A method as claimed in claim 9, wherein selecting a device further comprises using the generated measures to determine a probability for the nearest device to a desired position.

12. A method as claimed in claim 9, further comprising defining a threshold measure for a received signal strength for a device, and on the basis of the threshold determining if a measure of average received signal strength can be generated.

13. A method as claimed in claim 12, wherein a measure of average received signal strength is generated if the signal strength of respective ones of the received signals from the device are above the threshold measure.

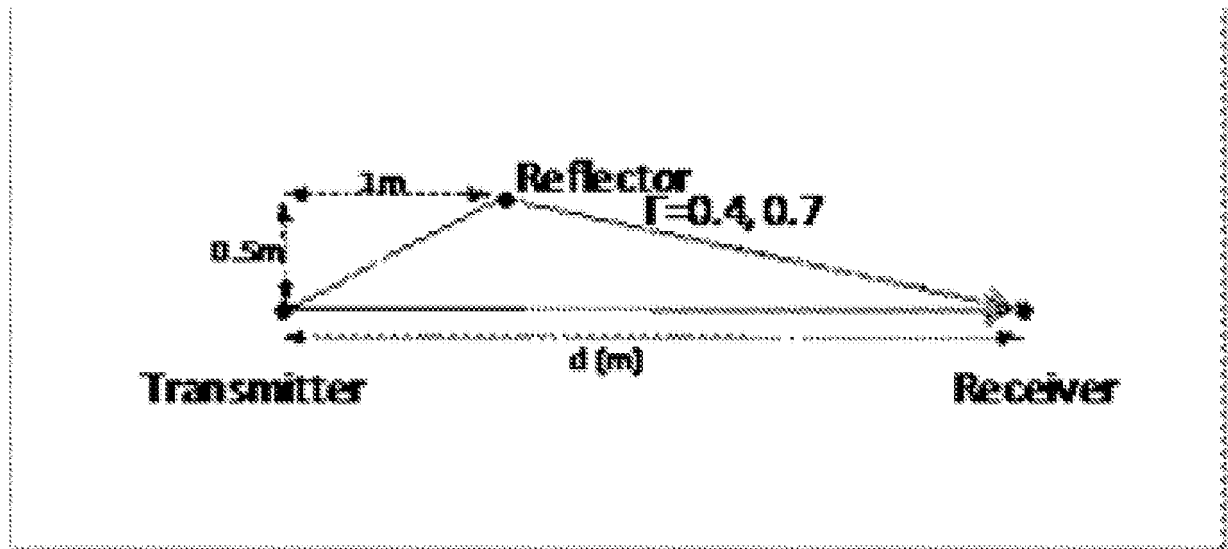


Figure 1a

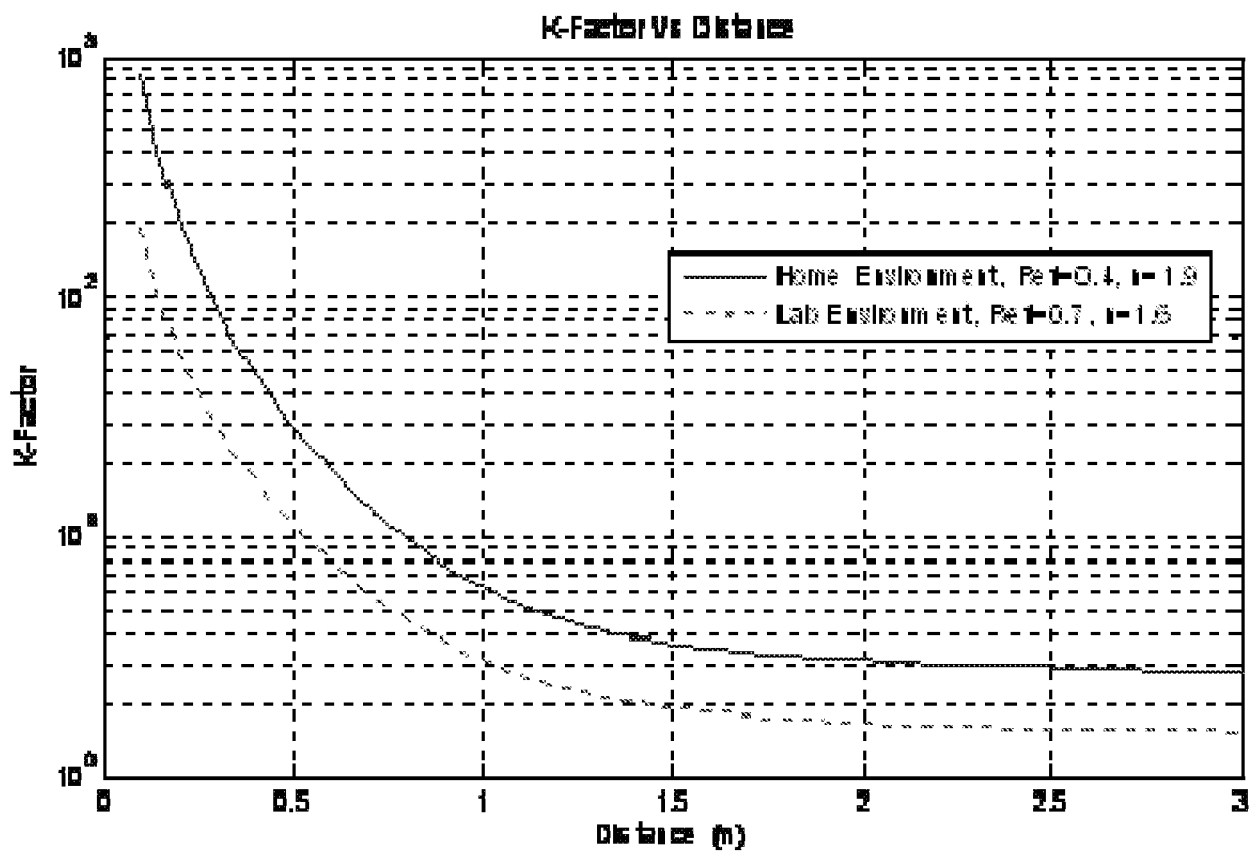


Figure 1b

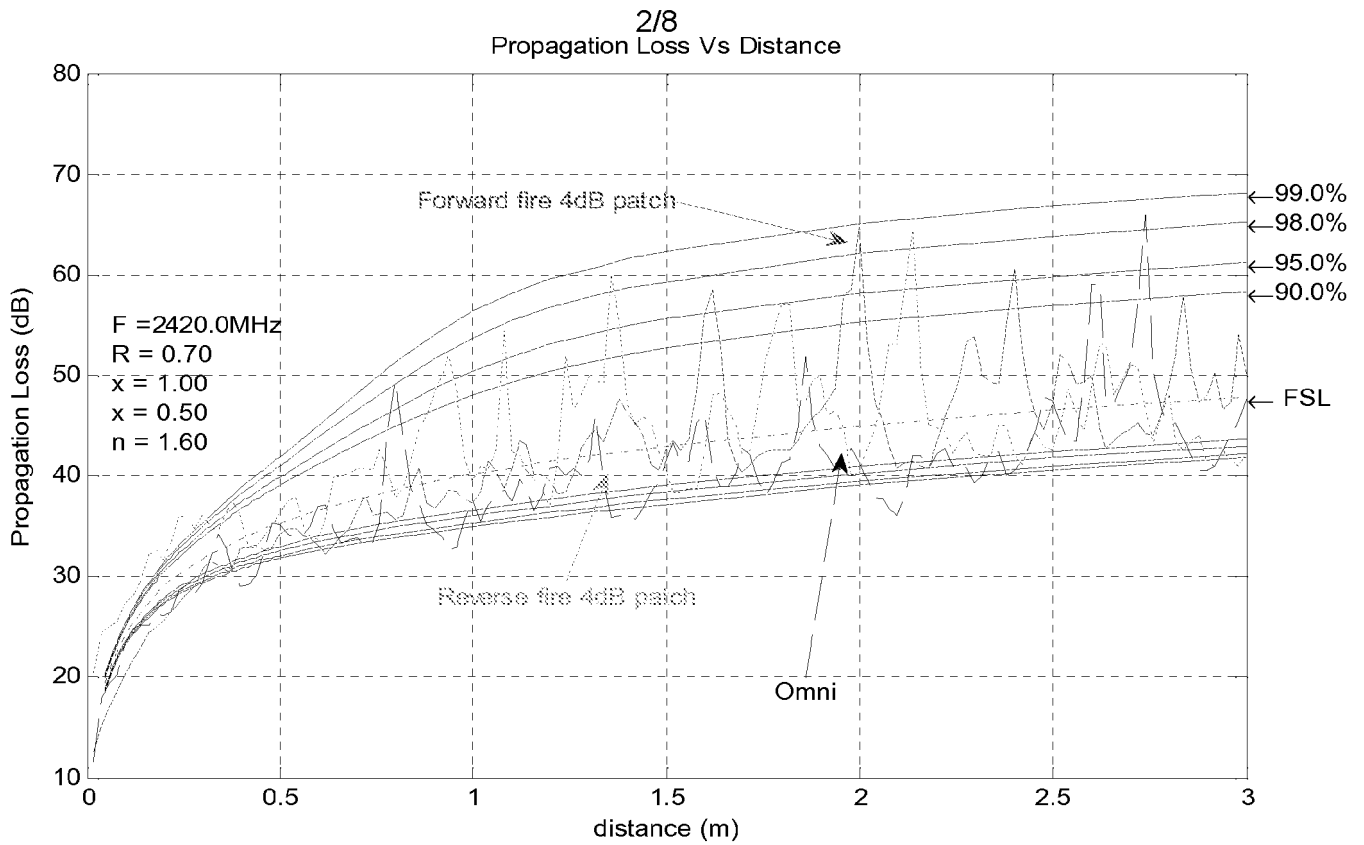


Figure 2a

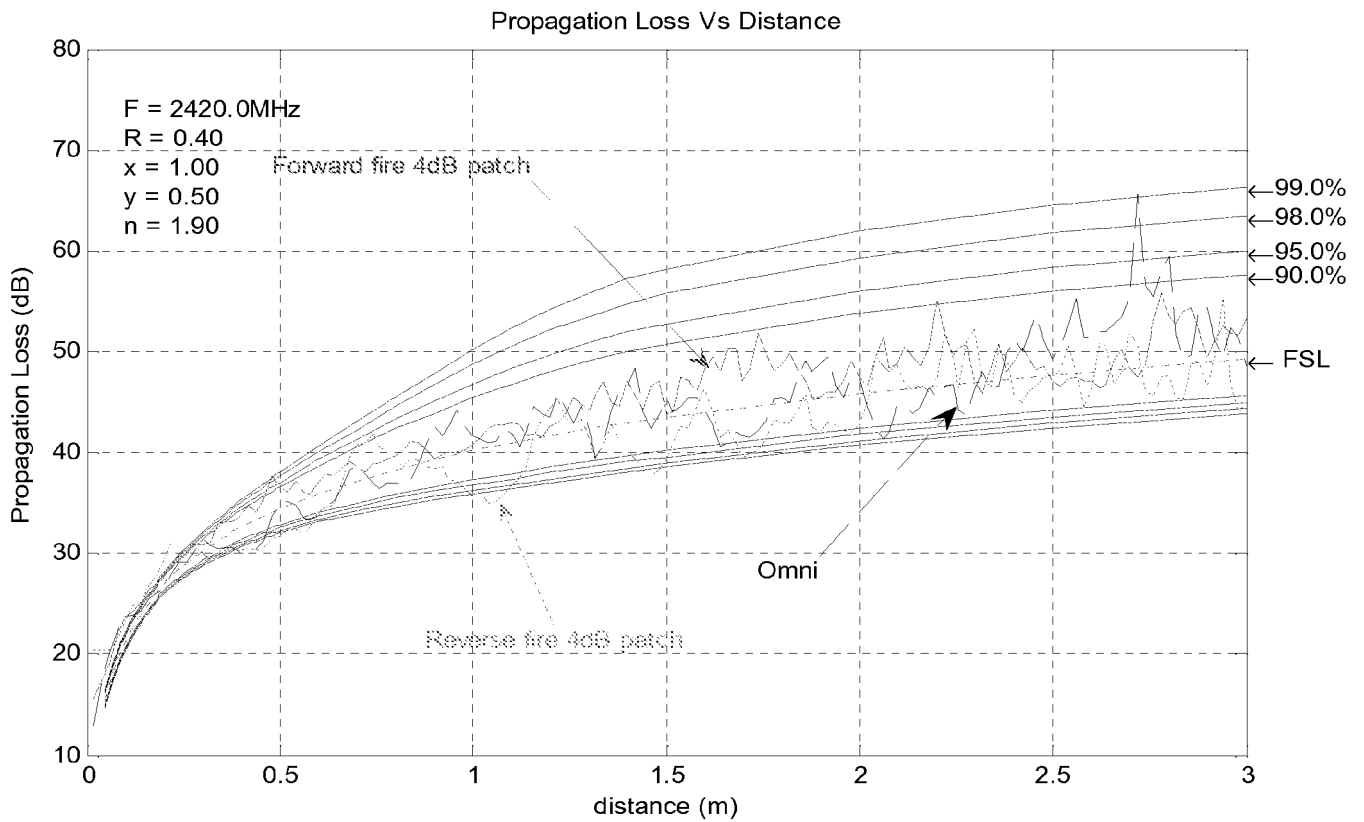


Figure 2b

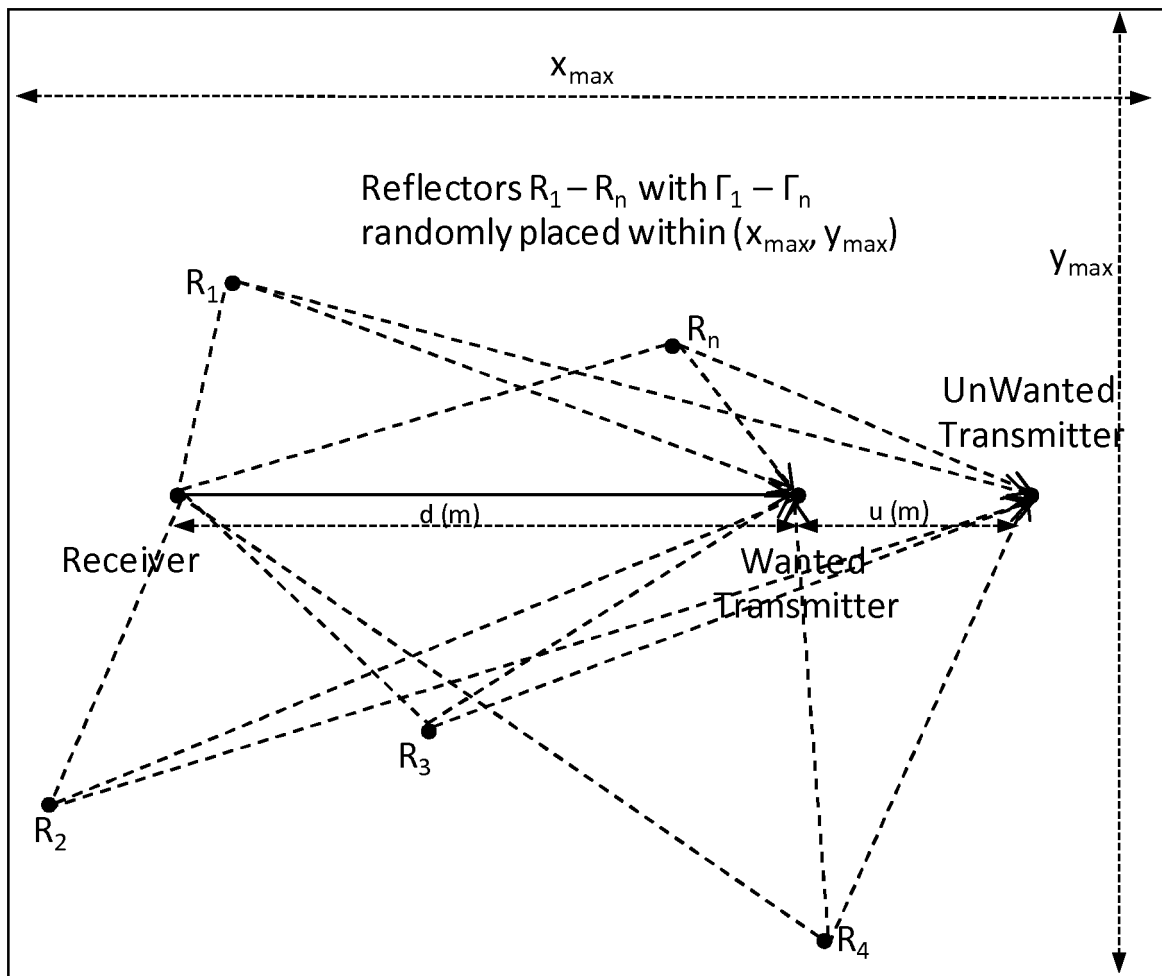


Figure 3

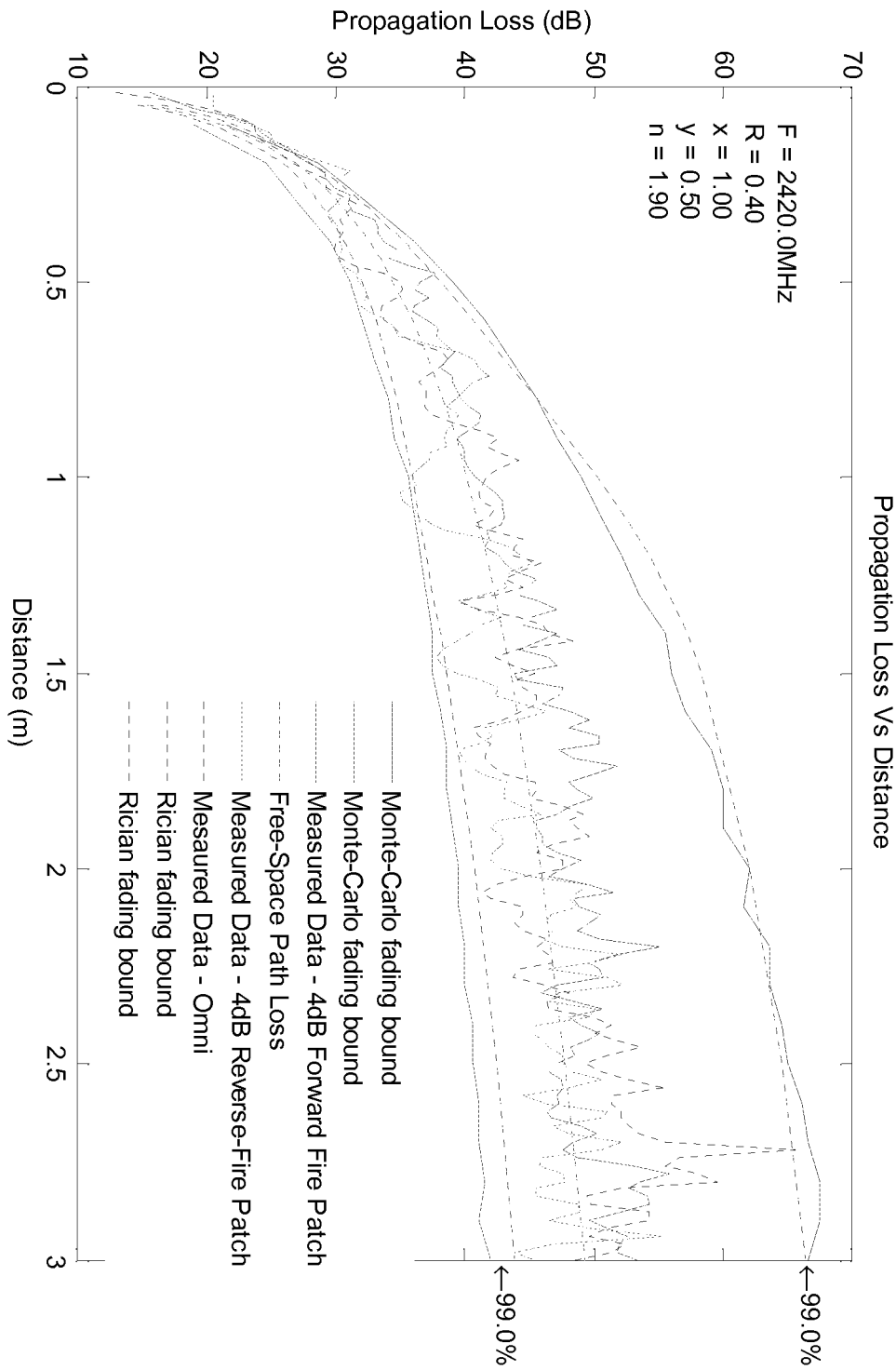


Figure 4

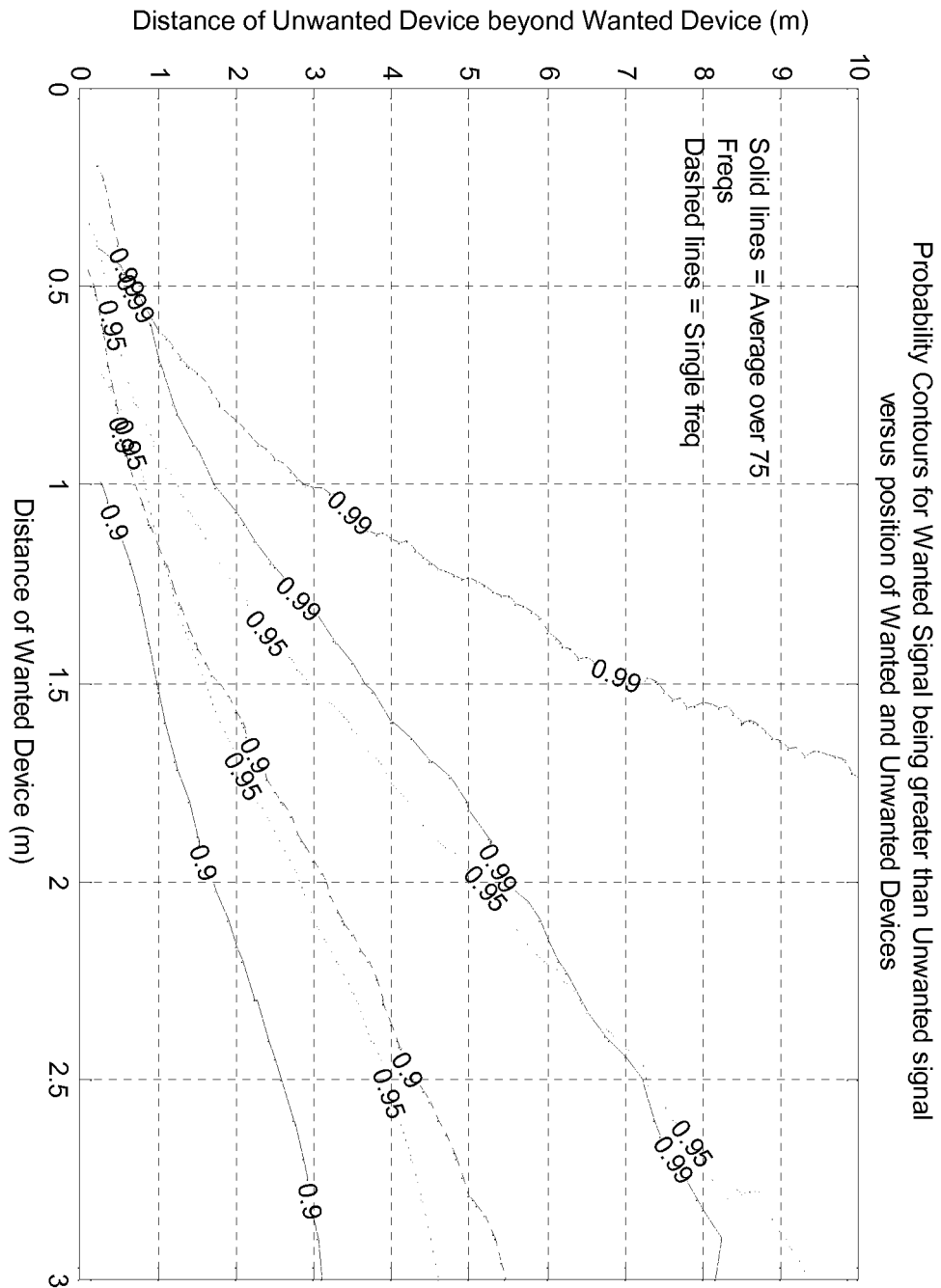


Figure 5

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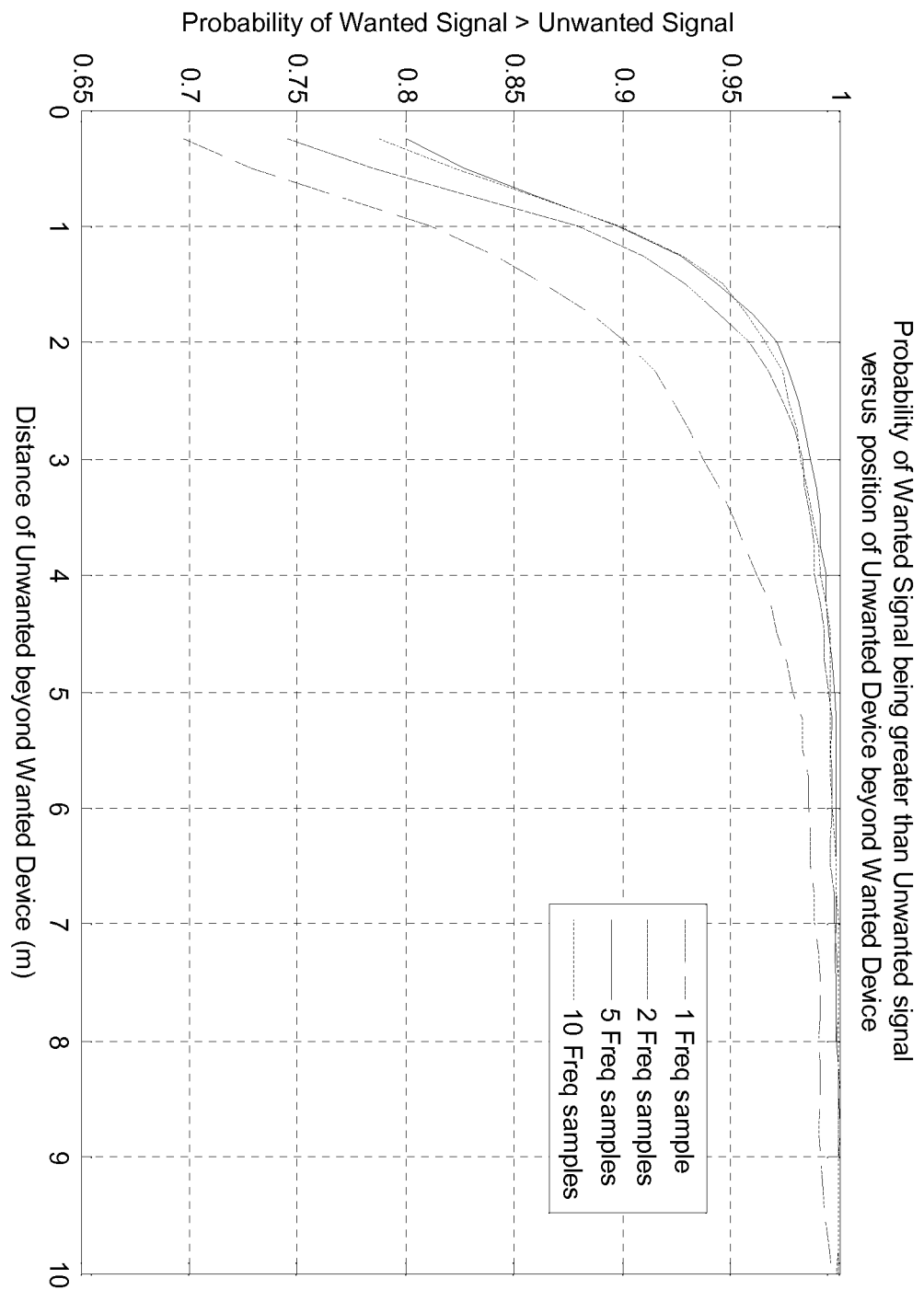


Figure 6

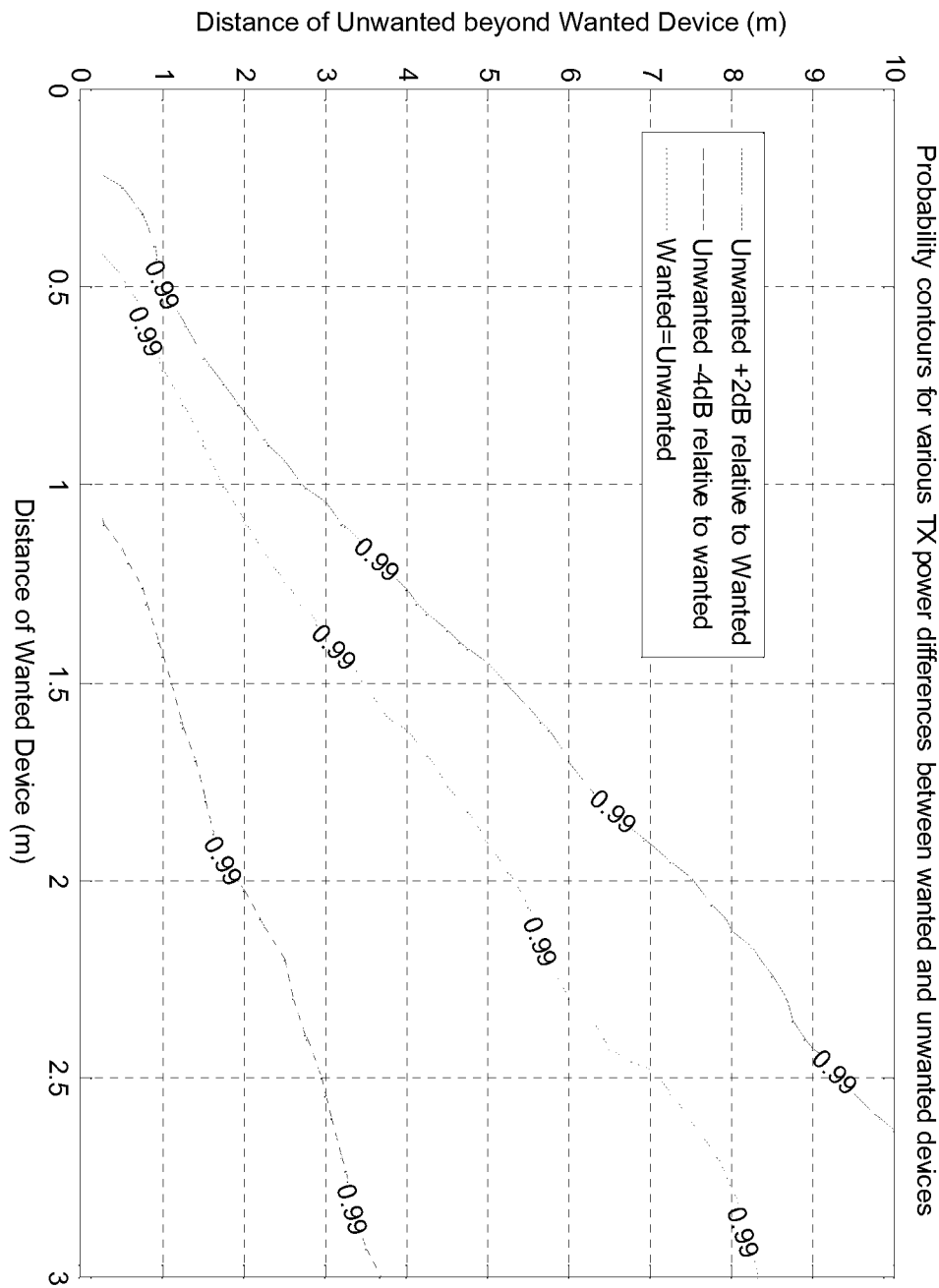


Figure 7

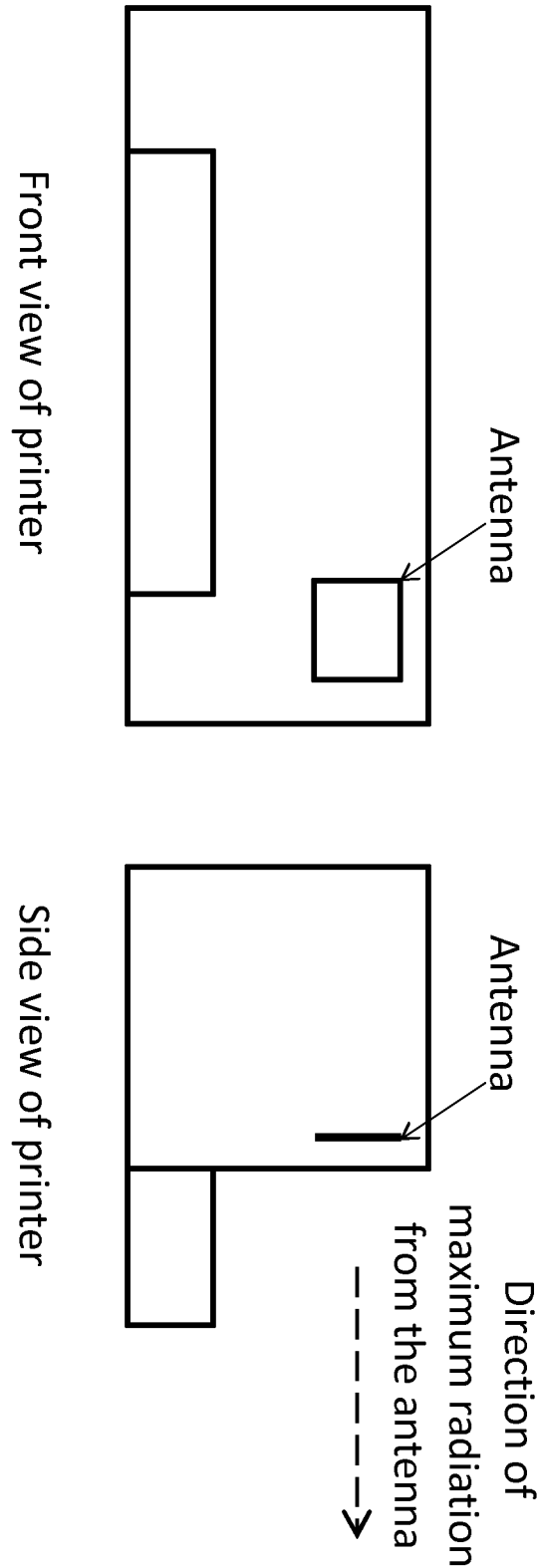


Figure 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/063607

A. CLASSIFICATION OF SUBJECT MATTER

INV. H04W8/00 H04B17/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04W H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/236850 A1 (KRUMM JOHN C [US] ET AL) 25 November 2004 (2004-11-25)	1-4,6-8
Y	* abstract	5,9-13
	page 4, paragraph 36	
	page 4, paragraph 38	
	page 5, paragraph 40 - paragraph 41	
	page 5, paragraph 44 - paragraph 47	
	figure 2	
Y	----- WO 2009/087521 A1 (KONINKL PHILIPS ELECTRONICS NV [NL]; BIRRU DAGNACHEW [US]) 16 July 2009 (2009-07-16)	5,9-13
A	page 1, line 16 - line 24	1-4,6-8
	page 2, line 1 - line 9	
	page 4, line 1 - line 22	
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Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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Date of the actual completion of the international search

14 July 2010

Date of mailing of the international search report

23/07/2010

Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2009/063607

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2005/227724 A1 (TSAI CHIEH-CHIH [TW]) 13 October 2005 (2005-10-13) page 1, paragraph 4 page 2, paragraph 19 - page 3, paragraph 22 page 4, paragraph 30 - paragraph 44 -----	1-13
A	US 2009/232120 A1 (MATTHES KATRIN [FR]) 17 September 2009 (2009-09-17) figure 8 page 1, paragraph 4 - paragraph 5 -----	1-13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2009/063607

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