Portal Field Strength Measurement Test Method Evaluation and Minimum Performance Recommendation

Version 1.0.0

Approved by the EPCglobal Technical Steering Committee and EPCglobal Business Steering Committee on July 14, 2009

Table of Contents

EXECUTIVE SUMMARY 4

1 OBJECTIVE....4

2 INTRODUCTION 4

3 MEASUREMENT RESULTS....5

4 SIMULATIONS 8

5 RESULTS AND DISCUSSION....8

5.1 Statistical analysis of measured data 8

5.2 Recommendation for applying the field measurement protocol test method ..9

5.3 Recommendation for minimum dock door portal field strength requirement..9

6 REFERENCES 9

Index of Figures

Figure 1: Frontal view of a doorway portal setup – positioning of antennas (labeled as 1, 2, 3, and 4) 4

Figure 2: Setup 7 - Test measurement points (dots and crosses) as viewed from above or the two tests (Note: not to scale) 5

Figure 3: Measured data of doorway portals field strength 7

Index of Tables

Table 1: Measured datasets showing corrected field strength values 6

Table 2: Statistical results for points C4 and C5 9

Executive summary

This document is a report of the Tag, Label, Reader and Printer Performance Working Group (TLRPP WG) of the EPCglobal HAG evaluated Revision 1.1 of the Portal Field Strength Measurement Test Method (referred to as “test method”) [1]. A series of measurements was taken on door portals to develop recommendations for a minimum performance requirement. The door portals tested were located in laboratory environments or in company distribution centers in both Europe and the United States. The results are reported in this evaluation and a recommendation is described.

1 Objective

Teams of RF engineers measured the electric field strength of each portal at the various locations specified by the protocol document. At least one field strength value was recorded per each point and setup. The results are provided in this document.

Finally, results of measurements were compared with a simulation model [4] and the WG agreed on a recommendation for minimum field strength at doorway portals.

2 Introduction

Portal setups at 11 different sites were evaluated. In this report the setups are referenced anonymously by number, *i.e.* Setup 1 through Setup 11, by request of the participants. Each setup consisted of four reader antennas. Positions of the antennas were recorded by measuring distances A, B, and C according to Figure 1.

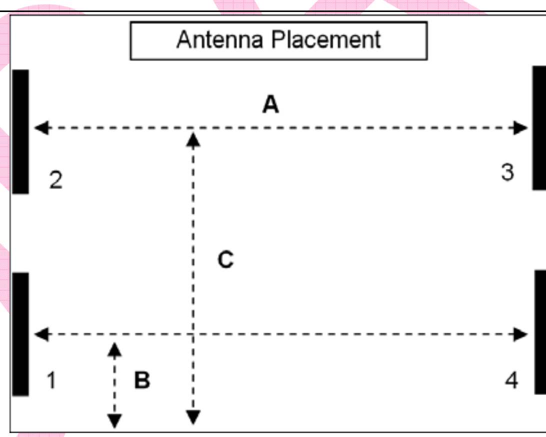

Figure 1: Frontal view of a doorway portal setup – positioning of antennas (labeled as 1, 2, 3, and 4)

The mechanical arrangement of the antennas was parallel to the plane of traffic, except for Setup 7.

In Setup 7 the portal antennas were tilted toward the receiving truck as shown in Figure 2.

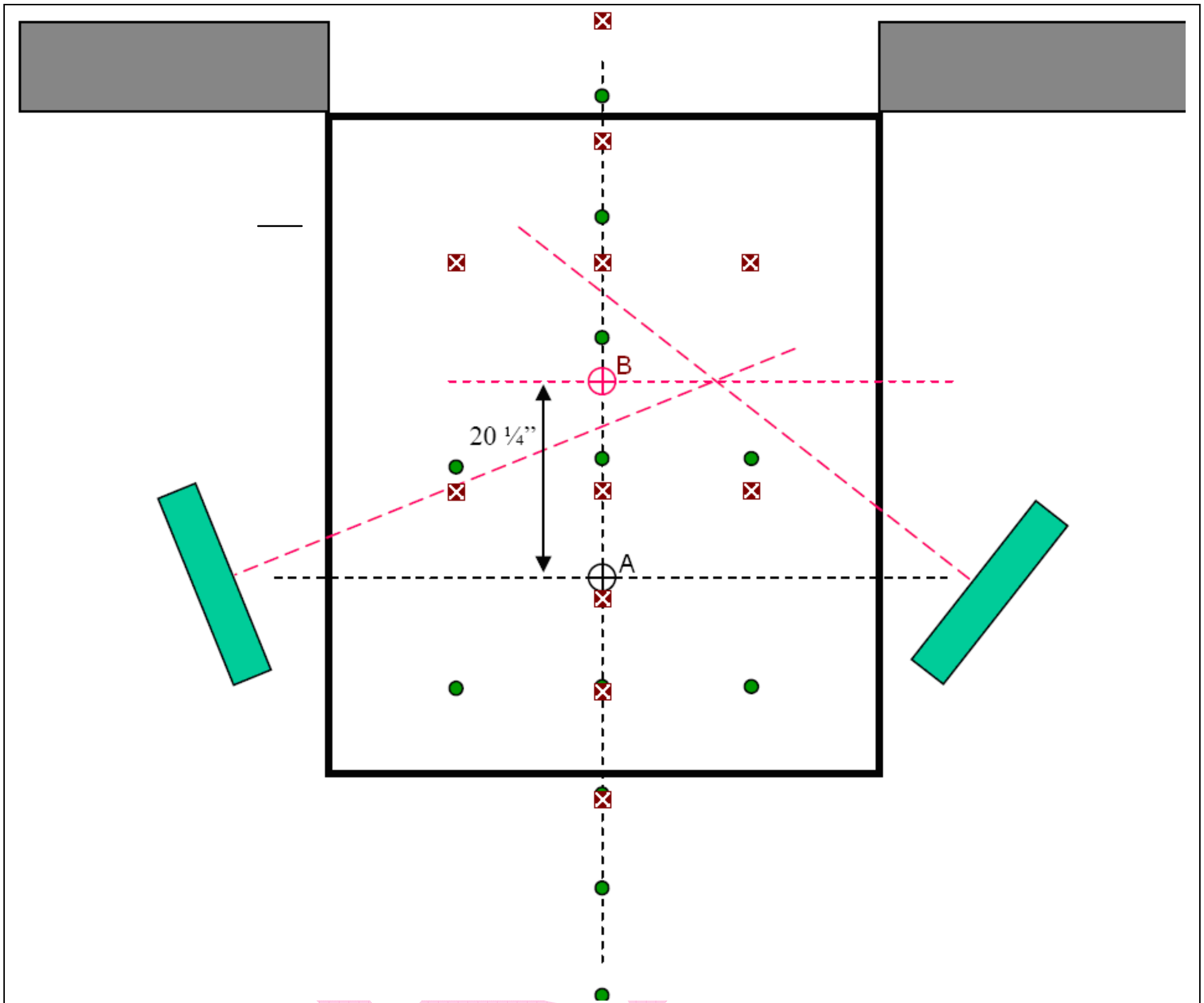

Figure 2: Setup 7 - Test measurement points (dots and crosses) as viewed from above or the two tests (Note: not to scale)

Two sets of measurements were taken in this setup [3]. First measurements were made with the center X-direction point positioned at the middle of the two sides of the portal (point A in Figure 2, with the dots). The second set of measurements was made according to the crosses in Figure 2, centered on point B. This second data set was collected to evaluate the effect of shifting the portal to accommodate for angling of the portal antennas. The location of the second center point is the point where the bore site projection of the two antenna main lobes cross each other and that point is shifted over to intersect the center of the plane of travel.

In Setup 11, the effect of proximity to a wall was analyzed by taking two sets of measurements with the portal being 48” (122 cm) and 68” (173 cm) away from a wall, respectively.

3 Measurement Results

For each point C1 through C8 (center), B1 through B4 (bottom), and T1 through T4 (top) the maximum field strength value in dBm was recorded according section 5.3 of the test method. Table 1 shows the corrected field strength values (column “E” values as defined in the test method).

Table 1: Measured datasets showing corrected field strength values

Center frequency	MHz	915	903	915	928	865	865	902 to 916	902 to 916	915	915	915	915	915
Antenna power	(dBm) linear		34	34	34	35.1	35.1	n/a	n/a	36	36	32.9	32.9	32.9
Antenna Placement:	A (m):	0.00	3.05	3.05	3.05	2.96	3.23	2.77	2.77	n/a	2.41	3.11	3.11	3.11
	B (m):	0.00	0.76	0.76	0.76	0.75	0.90	0.41	0.41	n/a	0.53	0.61	0.61	0.61
	C (m):	0.00	1.49	1.49	1.49	1.55	1.70	1.46	1.46	n/a	1.17	1.22	1.22	1.22

		Maximum Field Strength Values, corrected (dBm)												
Point	**Description**	**Setup 1**	**Setup 2**	**Setup 3**	**Setup 4**	**Setup 5**	**Setup 6**	**Setup 7 (Data set 1)**	**Setup 7 (Data set 2 - shifted points)**	**Setup 8**	**Setup 9**	**Setup 10**	**Setup 11 (48" from wall)**	**Setup 11 (68" from wall)**
C1	Center	-5.11	-12	-17.8	-12.3	-13.1	-15.6	-7.9	-1.14	-8.43	-5.36	-7.787	-9.1	-7.8
C2		-3.16	-11.8	-9.6	-12.8	-6.1	-9	-5.12	3.31	-3.73	-3.06	-3.263	-1.6	-4.3
C3		-0.48	-5	-7	-3	-4.2	-2.3	-1.23	5.13	-0.13	-0.86	1.033	2.2	-0.2
C4		0.24	-2.2	-4.6	-3.7	-2.1	1.4	2.39	5.72	0.17	0.84	1.29	2.6	2.6
C5		2.13	-3	-4.7	-3.5	1.1	0	5.8	5.14	0.17	3.04	2.49	2.9	2.9
C6		0.62	-4.8	-5.9	-6.9	-7.3	-5.1	2.95	1.2	-2.83	-3.66	0.64	0.7	3
C7		-0.44	-12.1	-8.8	-7.5	-8.5	-10.5	2.49	-0.01	-5.53	-3.06	-1.43	0.3	-1.4
C8		-1.58	-11	-11.8	-11.4	-13	-10.8	0.81	-3.39	-9.03	-4.16	-5.953	-6	-4.5
B1	Bottom	3.43	-1.3	-3.3	-2.3	2.3	-5.2	2.42	7.71	4.87	0.84	4.537	4.9	5.4
B2		6	-2.3	-2.9	-3.3	-0.2	-7.9	6.5	4.29	5.07	0.84	4.337	4.6	5.4
B3		3.17	-2.6	-6.2	-3.4	1	-2	1.43	8.6	0.07	4.64	3.777	5.2	4.8
B4		5.56	-5.3	-1.7	-0.4	2	-2.8	7.46	5.21	-0.03	3.04	4.79	6.3	6.3
T1	Top	3.66	-5.8	-4.5	-4	-1.2	-3.6	0.51	7.31	0.17	-0.36	1.637	2.8	1.5
T2		5.28	-5.5	-2.4	-4.7	-3.8	0.2	5.15	2.61	1.97	-0.86	2.927	3.1	3.2
T3		2.78	-3.3	-6	-5.8	-2.6	-1.6	0.62	8.37	1.87	3.04	3.337	3.9	2.5
T4		4.5	-0.7	-3.8	-3.9	-1	-2.5	5.41	3.13	0.37	-0.36	2.74	3.5	3.8

Figure 3 shows the corrected maximum field strength values measured in individual measurement points in different setups.

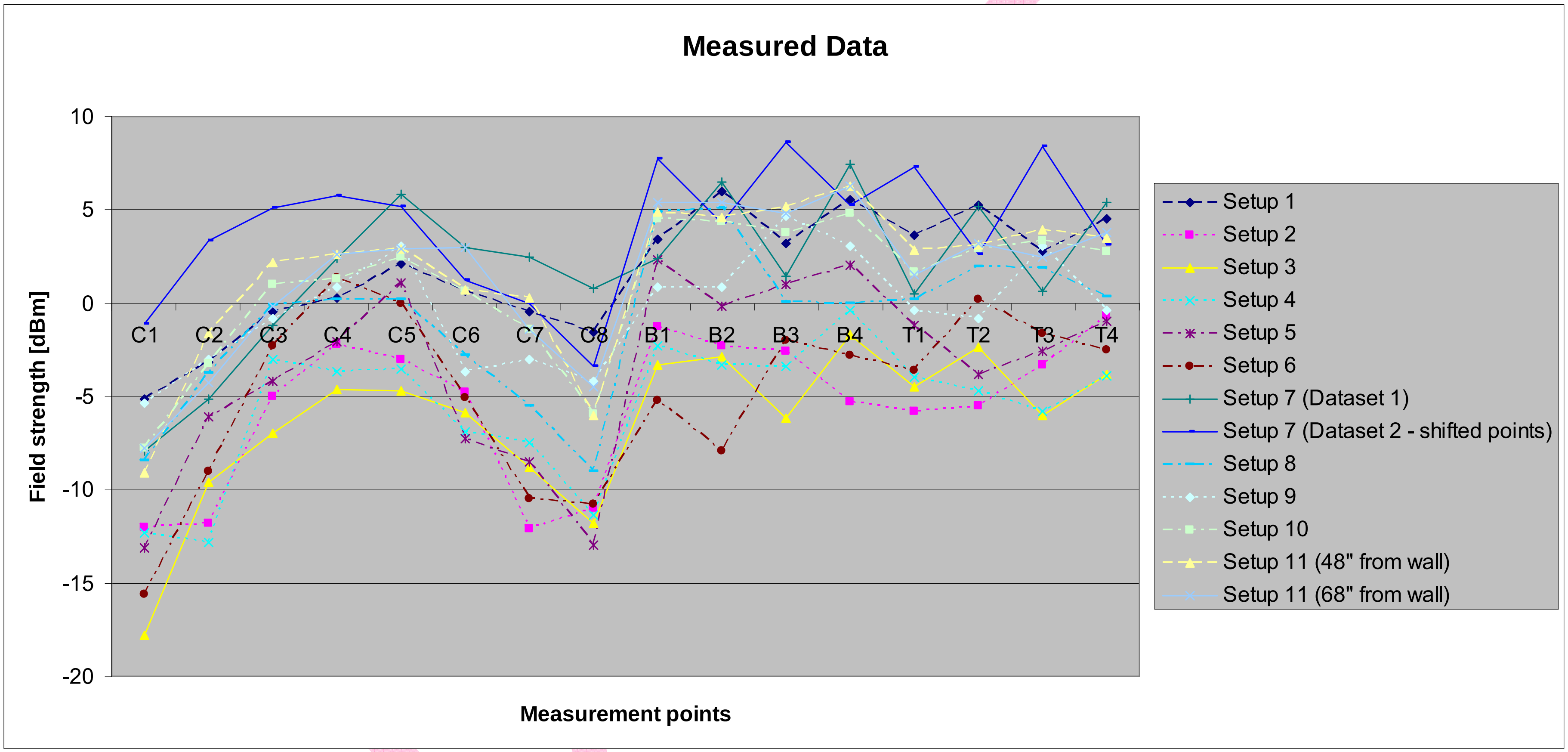

Figure 3: Measured data of doorway portals field strength

4 Simulations

Due to the reflective nature of objects located in typical application setups, a reflected signal has an influence on field distribution. A two-ray linear propagation model [2] was used to consider two paths of the signal - direct signal path and path of a signal reflected off of the floor. Linear polarization was used to reduce the complexity of calculations.

Below is a summary of assumptions for the antennas in the simulation:

- Due to unknown radiation characteristics of the antennas used, isotropic radiators were assumed in simulations.
- For data sets that did not provide information about maximum reader antenna output power, antenna type and gain, the maximum output power was assumed for the respective region (in this case, 36 dBm for US)
- Setup 8 was excluded from simulations, because 1 measurement did not provide information about dimensions of the portal setup / reader antenna distances.

5 Results and Discussion

Results of the simulations [4] showed that the antenna positioning, namely the antenna height, has major impact on the field distribution in a free-air doorway portal setup. It was found that the antennas of the evaluated portal setups were installed such that the field measured in the points, which are defined in this test method, was close to the maximum achievable values.

The maximum field strength is found at the top and bottom points for most data sets. The only exception is the data set for Setup 6, in which the maximum field strength was measured in the center of the portal.

Since the dock platform of the door portal may be ungrounded, the bottom points can vary significantly from one location to another. Although the top points' field strength will vary from portal to portal due to the vertical location of the top antennas, it is advised that the top points remain at 46 inches (116.8 cm) above the floor. These points were chosen based on the pallet dimension being 40 inches (101.6 cm) high. By fixing the height of these measurement points, comparisons can be made between portals and portals can be optimized for a fixed pallet size.

5.1 <u>Statistical analysis of measured data</u>

A statistical analysis was applied to the measured datasets in order to develop a final recommendation for performance requirements. The values of field strength in dBm(Watt) were converted into values of electric field strength according [5] using the equation 5.1.

$$E = \frac{4\pi}{\lambda} \cdot \sqrt{\frac{30P_r}{G}} \text{ [V/m]} \qquad 5.1$$

where

P_r is the received power [W]

G is the gain[i] of the probe antenna []

λ is the wavelength of the measured RF signal [m]

The mean value and standard deviation of the electric field strength was calculated for measurement points C4 and C5, which are located on the center line closest to the doorway plane. These values were then converted back into dBm(Watt)[ii] with the following results:

[i] Unity gain (G = 1) is used for the computation as the E-field results in dBm are provided values that were compensated for probe antenna gain.

Table 2: Statistical results for points C4 and C5

	Mean [dBm]	Standard deviation [dBm]
C4	0.84	2.63
C5	1.69	2.61
(C4+C5)/2	1	3

In summary, the absolute minimum field strength level measured was -5 dBm, the mean value was +1 dBm and the standard deviation was 3 dBm.

5.2 Recommendation for applying the field measurement protocol test method

The Field Strength Measurement Test Method can be applied also for modified location of measurement points to account for portal antennas that are not parallel to the plain of traffic. The modification of the measurement points locations is as described in this document for Setup 7 data set 2, where the beam center is projected onto the center line of the plane of travel.

5.3 Recommendation for minimum dock door portal field strength requirement

The workgroup discussed the results, and based on observation of data falling within -5 to 6 dBm at the center of the portal, a recommendation for minimum dock door portal field strength requirement was formulated. The shifted data in setup 7 have mainly an impact on measured values in bottom (B) and top (T) points, however the field shape measured in the center of the portal correlates to the other 8 data sets and therefore the data is considered valid for now.

A well-designed RFID portal gate should provide a field of at least -5 dBm, measured in the center of the portal at the height of 26 inch (66 cm) above the ground using a calibrated fixed-length dipole antenna, which is positioned horizontally along the centerline (movement path). Furthermore, field of -5 dBm is defined as permissible, -2 dBm as good, and +1 dBm as excellent.

6 References

[1] EPCglobal™ (14 February 2006) Portal Field Strength Measurement Protocol, Rev 1.1 (working draft); http://www.epcglobalinc.org/apps/org/workgroup/hag_tlrpp_wg/download.php/9686/EPCGlobaPortalFieldMeasurementProtocol_02_14_2006.pdf

[2] Chang-Fa Young; Chuen-Jyi Ko; Boau-Cheng Wu; Field measurements and ray tracing simulations for indoor wireless communications; Personal, Indoor and Mobile Radio Communications, 1996. PIMRC'96. , Seventh IEEE International Symposium on Volume 3, 15-18 Oct. 1996 Page(s):776 - 780 vol.3

[3] Jeffrey Hazen, Field Strength Testing report; Jan. 2007; http://www.epcglobalinc.org/apps/org/workgroup/hag_tlrpp_wg/download.php/6971/FST%20in%20TylerTX.pdf

[4] Jan van Niekerk, Two-Ray Path Model 915 MHz; http://www.epcglobalinc.org/apps/org/workgroup/hag_tlrpp_wg/download.php/12795/Theoretical%20Distance%20%20Power%20Calculator.xls

[5] C. A. Balanis, Antenna theory, analysis and design Wiley, 1997, chapter 2

[ii] Assuming center frequency of 900 MHz

7 Revision History

Date & Version Number	Section(s)	Change	Edited by
July 31, 2008 Version 1.0.0	All	Original document	V. Derbek