Body Loss Measurements of Internal Terminal Antennas in Talk Position using Real Human Operator

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Abstract

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Index Terms
Inspec

Controlled Indexing

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Non-controlled Indexing

PIFA antenna   body loss measurement   internal mobile phone antenna   monopole antenna   real human operator   talk position

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Body Loss Measurements of Internal Terminal Antennas in Talk Position using Real Human Operator

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Abstract

Measured results of three typical internal mobile phone antennas held in talk-position by a real human operator are presented. Depending on exact placement of index finger, frequency band and type/position of radiator, total body losses ranging from 6-26 dB have been measured. In all cases, the absorption loss was much more significant than the mismatch loss. The monopole (off-ground) antenna was more affected by the head+hand than the PIFA antennas, in particular for the common placement in the bottom of the phone.

1. Introduction

Modern mobile phone antennas are designed for and characterized in both free-space and talk position. While the free-space condition is uniquely defined, easily achieved in practice (with reasonable accuracy) and ensures highly repeatable measurements, talk position is a much more complicated and diverse case. To retain some consistency, documents from standardization associations [1] and wireless carriers are available that defines suitable measurement procedures for talk position. Here, a hollow head phantom is filled with tissue simulating liquid, and the phone is positioned according to specified reference points. As long as care is taken to keep the liquid parameters within limits, ensuring that the phone is firmly pressed against the phantom and that the cable (if used) is reasonably decoupled from the antenna, such measurements are generally sufficiently repeatable. However, in the present specification documents, only the head effect is taken into account; no mentioning of the hand is made. While phantom hands are available and are sometimes used during measurements (e.g. by request from phone manufacturers), they introduce a large measurement uncertainty and reduction of repeatability because of the difficulty of adjusting the hand into the desired shape repeatedly. The way a particular phone is held in practice is also a function of its form factor and specific industrial design, so devising a general grip is probably not feasible. The exclusion of hand effects in standardization documents is therefore well motivated. Unfortunately, this has also led to a lack of experience of the impact of the hand effect on the antenna performance in real life. Reports of body losses (head+hand) varying by 10 dB for different users in the same environment was reported in [2]. This variation was later concluded [3] to be caused by variations in the specific grip and position of the phone between different users, as opposed to differences in user anatomy. With the grip specified, a variation of only 0.2 dB at GSM1800 was detected between 3 different users of diverse height, weight and age. The total body losses (including mismatch) in [3] was ~ 4 dB for head+hand and ~ 1.5 dB for head only at 1800 MHz, using a fairly loose grip. In contrast, Boyle [4] presents body losses from similar experiments of more than 11 dB (with unknown phone grip). Depending on grip, and presumably radiator implementation, variations in losses up to 7 dB can therefore be expected.

In this paper, we present results from three prototype antennas measured in talk position using a real human operator placed in a 3D pattern measurement chamber (Stargate-64 from Satimo), a method that has previously been validated for such measurements [5]. All antennas have similar form factors and plastic shielding, and are held in identical positions by the operator thus simplifying the comparison of results. A commercially available phone using a similar antenna as the prototypes was used as benchmark, and one measurement was repeated after 2 weeks with a different operator to test repeatability.

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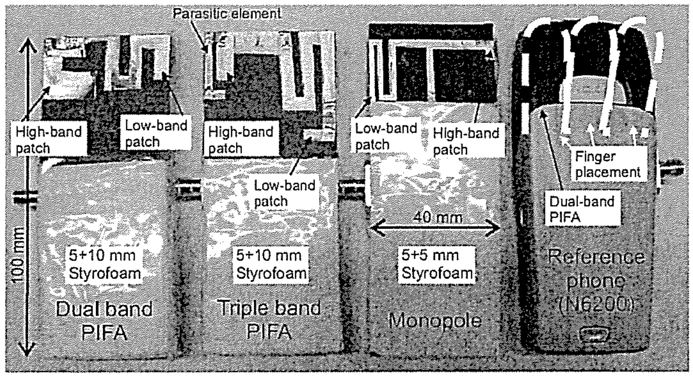


Figure 1: Photograph of back (antenna) side of Antennas Under Test.

Table 1: Frequency limits and efficiency of Antennas Under Test in free-space

	Frequency Limits		Total Efficiency (dB)	
Antenna	Low Band	High Band	Low Band	High Band
Dual band PIFA	871-1030	1724-1876	-(0.9–2.9)	-(1.4–2.7)
Triple band PIFA	857-919	1690-1966	-(1.5–2.9)	-(1.8–3.8)
Monopole	859-1058	1697-1896	-(1.7–2.4)	-(1.7–3.2)
N6200	822-884	1784-2000	-(3.9–5.9)	-(3.2–4.5)

2. Experiment Description

2.1 Prototype Antenna Design

Three prototype antennas, all representative of typical modern phones, have been examined: a dual band 900/1800 MHz PIFA, a triple band 900/1800/1900 MHz PIFA using a parasitic element, and a monopole 900/1800 MHz. All phones are of monoblock type, using a naked 100x40 mm^2 single-sided FR-4 PCB as chassis. The radiators are mounted on hollow plastic (ABS) carriers, with 7 mm thickness for the PIFA-antennas and 4 mm for the monopole. Styrofoam is used as space filler, providing a 5 mm chassis-hand distance on the front-side and 10 mm (5 mm for monopole) on the back side. A 1 mm thick plastic top is placed on top of the radiator. The antennas under test are shown in Fig. 1.

All antennas are designed for minimum complexity to simplify analysis. Dual-band functionality is implemented by using two unequally sized galvanically coupled resonant patches (or branches). A short patch is resonant at 1800 MHz and a longer, bent patch is resonant at 900 MHz, as indicated in Fig. 1. A triple band response is achieved in the second prototype by adding a $\lambda/4$ short-circuited element close to the feed point. The monopole prototype extends 20 mm from the short-edge of the 80 mm chassis ground, and is also based on two branches connected in parallel for dual band coverage. The feed and short-circuit pins are located in the corner of the upper short-edge of the PCB for the PIFA prototypes, and the feed pin of the monopole is located in the center of the upper short-edge of the PCB (no short-circuit is used for the monopole). For each antenna, the location of the open ends of the two branches are well separated. Hence, it is not possible to place the finger on both open ends simultaneously. Furthermore, the use of slots have been minimized as they could potentially be short-circuited by the finger and thereby complicating the results in talk position.

2.2 Measurement Details

All three prototype antennas were measured in talk position with the operator's index finger placed on, and extending slightly past, the antenna in three different positions, as indicated schematically in Fig. 1 and shown for the case of the right-most placement in Fig. 2 (center). The phone grip is shown in Fig. 2 (right). For the monopole antenna, an additional grip was used with the phone turned up side

Figure 2: Photograph of operator holding phone during measurement.

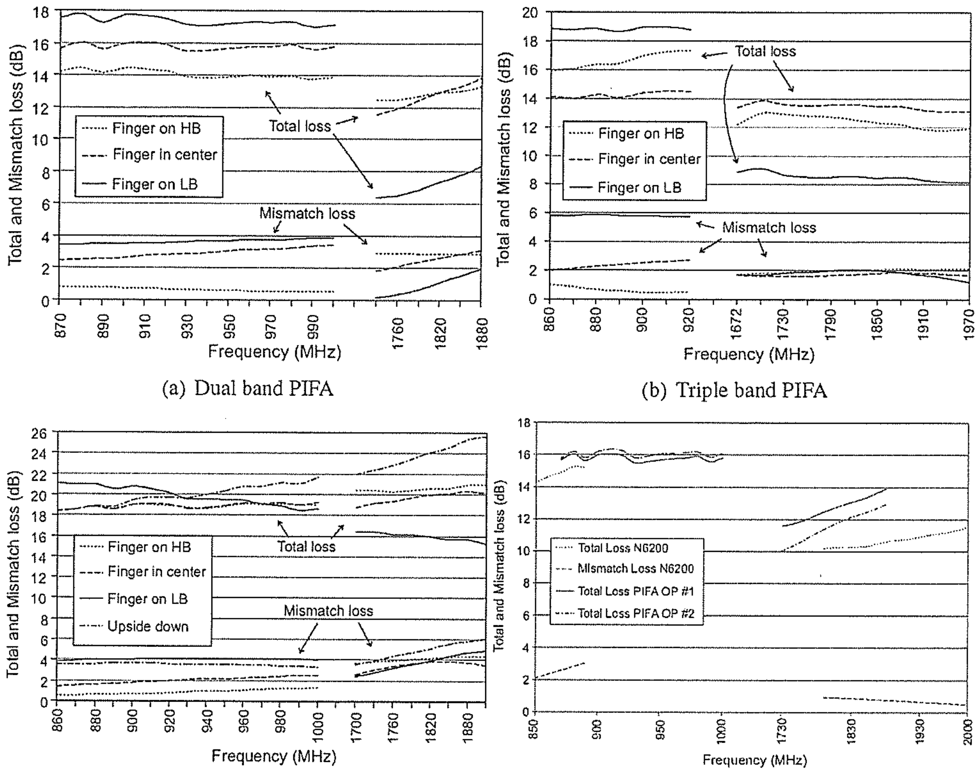
down, i.e. with the antenna in the bottom of the terminal. The coaxial cable was connected perpendicular to the chassis length at the simulated E-field minima at 900 MHz to minimize the cable influence, and the cable was further decoupled from the chassis by a dual band balun (as in [6]). The operators elbow was placed on the chair's arm-rest to fixate the position during one measurement rotation (360^o), and as one turn took less than 5 minutes the body position could be kept fairly constant throughout. The terminal was positioned as close to the center of the measurement arch (i.e. the calibration point) as possible to minimize distance errors. Immediately after each radiation measurement was complete, the return loss was measured in the exact same operator position for mismatch loss calculation. In addition to the prototype antennas, a commercially available mobile phone (Nokia 6200) was also tested as reference. The measurement results are shown in Fig. 3, including the losses of the dual band PIFA prototype with the finger in center position measured using a different operator ("OP #2" in Fig. 3) two weeks after the first measurements. In Fig. 3, HB means "High Band patch/branch" and LB means "Low Band patch/branch", i.e. either the left-most or right-most side of the radiator. The results of each antenna is presented at the frequency bands (around 900 and 1800 MHz) where the return loss was below -6 dB in free-space.

Table 2: Summary of measured losses of Antennas Under Test

	Low Band				High Band			
	Total loss		Mismatch loss		Total loss		Mismatch loss	
Antenna	Average	Range	Average	Range	Average	Range	Average	Range
Dual band PIFA	16	14-18	2.5	0.5-4	11	6.5-14	2	0-3
Triple band PIFA	16.5	14-19	3	0.5-6	11.5	8-14	2	1-2
Monopole	19.5	18.5-21.5	2.5	0.5-4	20	15-25.5	4	2.5-6
N6200	15	-	2.5	-	10.5	-	0.5	-

3. Results and Conclusions

In agreement with [4], the body losses in talk position has been shown to be very dependent on the hand position, and in particular the exact placement of the index finger on the antenna element. For PIFA antennas at 900 MHz, an absorption loss of 14 dB + mismatch loss of 0-4 dB has been measured. For PIFA antennas at 1800 MHz, the absorption was 6-11 dB + 0-3 dB of mismatch loss. These results are in the same range as [4], and also agrees well with the reference antenna (N6200). No significant difference between the antennas with and without parasitic elements was noticed. The monopole had much higher losses, both absorption and mismatch, than the PIFA, and in particular with the antenna element in the bottom position. The results of two different operators of different height and weight, measured at two different times, were nearly identical at 900 MHz and differed by <1.5 dB at 1800 MHz, in close agreement with [3]. For all antennas, the open end of the patch/branch is most sensitive



(a) Dual band PIFA

(b) Triple band PIFA

(c) Monopole

(d) N6200+repeatability test

Figure 3: Measured losses of Antennas Under Test in talk position.

to the finger effect, and at all frequencies the absorption loss is much larger than the mismatch loss. No attempt at separating the hand effect from the head effect has been made in this paper.

References

[1] Cellular Telecomunications & Internet Association, "Method of Measurement for Radiated RF Power and Receiver Performance", Test plan for mobile station over the air performance, Rev. 2.2, Nov 2006.

[2] G.F. Pedersen, J.O. Nielsen, K. Olesen and I.Z. Kovacs "Measured variation in performance of handheld antennas for a large number of test persons", Proc. IEEE Vehicular Technology Conf., Ottawa, pp.505–509, May 1998.

[3] J. Krogerus, C. Icheln and P. Vainikainen, "Effect of Human Body on 3-D Radiation Pattern and Efficiency of Mobile Handsets", Proc. IEEE Instrumentation and Measurement Technology Conf., , Ottawa, pp.271–276, May 2005.

[4] K.R. Boyle, "The performance of GSM 900 antennas in the presence of people and phantoms", Proc. Int. Conf. Antennas and Prop., Vol. 1, pp.35–38, Exeter, April 2003.

[5] J. Krogerus, K. Kiesi and V. Santomaa, "Evaluation of three methods for measuring total radiated power of handset antennas", Proc. IEEE Instrumentation and Measurement Technology Conf., Budapest, pp.1005–1010, May 2001.

[6] P. Lindberg, M. Sengul, E.G. Cimen, B.S. Yarman, A. Rydberg and A. Aksen, "A single matching network design for a dual band PIFA antenna via simplified real frequency technique", Proc. European Conf. on Antennas and Propagation (EuCAP), Nice, Nov 2007.