MEASUREMENT WITH THE PRESENCE OF AMBIENT DISTURBING SIGNALS

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ABSTRACT

Pre-compliance testing is a way how to save money and time during development of electronics. Pre-compliance test sites have two major problems: test site "imperfections" and ambient disturbing signals. These complications are independent on each other and should be solved separately. This paper shows some methods and principles to deal with ambient disturbing signals the important ideas of the paper.

1. PRE-COMPLIANCE TESTING

Pre-compliance radiated disturbance measurement has two complications, reflections at "imperfect" test site and ambient disturbing signals, so called "ambients". Pre-compliance tests are usually done in common labs, rooms, OATS, etc., and they are not performed in semi-anechoic or shielded chamber due to high costs. Result of the missing shielding is the presence of ambients. Ambients can be caused by radio broadcasting, free radio bands, cell phones, random signals (industry, traffic, atmosphere…), etc. There are at least four methods for determine presence and level of EUT (equipment under test) signals hidden in ambients.

1.1. OFF-TUNING THE EMI RECEIVER

Frequency, eventually measurement receiver (analyzer) bandwidth is tuned to filter ambient disturbing signal, but not the EUT signal. This method is reliable by narrowband ambients and for frequencies different from EUT signal frequencies.

In some cases is it possible to estimate disturbance level even in case when disturbance and EUT signal are at the same frequency

1.2. SIGNAL SUBSTITUTION

This method is suitable for EUT and disturbing signals with narrow band and where signals are very close in frequency so the off-tuning method can not be used. Disadvantage of *signal substitution* and *off-tuning the EMI receiver* methods is that these methods do not operate with modulated signals and phase shifts are not considered.

1.option:

Measurement of **EUT signal + ambient disturbing** is done at chosen frequency. EUT is displaced by signal generator and suitable transmitting antenna. Generator signal level is set so, that when there will be the same measured level on the receiver, then EUT radiated power P_r (without ambients) is determined by

$$P_r[dBm] = P_G[dBm] - L[dB] + G_{TA}[dB], \quad (1)$$

where P_g is signal generator output power
L is cable attenuation between antenna and generator
G_{TA} is transmitting antenna gain.

2.option:

Measurement of **EUT signal + ambient disturbing** is done at chosen frequency. EUT is shut down and signal generator is connected directly to the measurement receiver (still receiving ambients). Signal generator level is set so, that receiver readings are the same as at EUT measurement. Than the EUT radiated power P_r (without ambients) is determined by

$$P_r[dBm] = P_G[dBm] - L[dB], \quad (2)$$

where P_g is signal generator output power
L is cable attenuation between antenna and generator.

This option is two times faster then the previous one.

1.3. SHORTENING THE MEASUREMENT DISTANCE

Level of measured EUT signals compared with ambient disturbing signals is relatively increased by shortening of the measurement distance. For example shortening from 10 m to 3 m (3 m to 1m) increases electric field intensity of EUT signals of 10,5 (9,5) dB.

Figure 1: Test equipment displacement in the meeting room.

In the same way is necessary to recalculate limits determined by EMC standards. Beware of measurement distance below 1 m because results could be influenced by measurement in electromagnetic near field zone.

My measurement was made with shortening from 3 to 2 meters. At 2 m distance the levels of electric field measurement should be higher of 3.5 dB calculated by

$$\Delta E[dB] = 20 \cdot \log\left(\frac{r_{NEW}[m]}{r_{ORIG}[m]}\right)[dB], \tag{3}$$

where r_{NEW} is for shorter distance

r_{ORIG} is for original distance of 3 meters.

I used an emission reference source (ERS) as a disturbance source. This ERS should transmit at frequencies from 30 to 1000 MHz with 2 MHz spacing. But this one is little bit faulty and I stopped the measurement at 800 MHz because above this frequency the ERS output power is not sufficient enough to be detected. In the figure 1 is shown measurement equipment displacement in the meeting room.

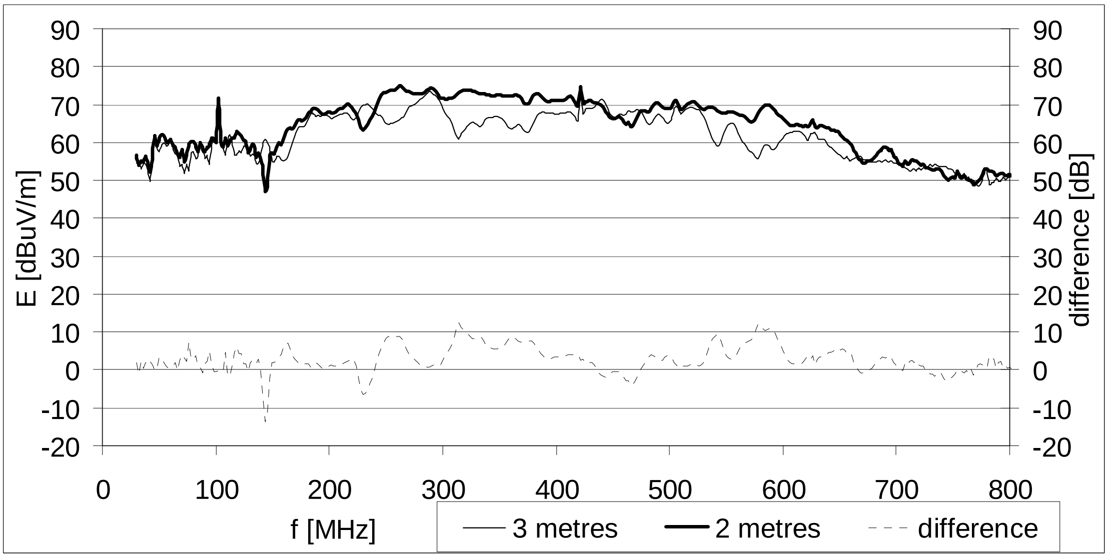

Figure 2: Shortening from 3 m to 2 m, horizontal polarization.

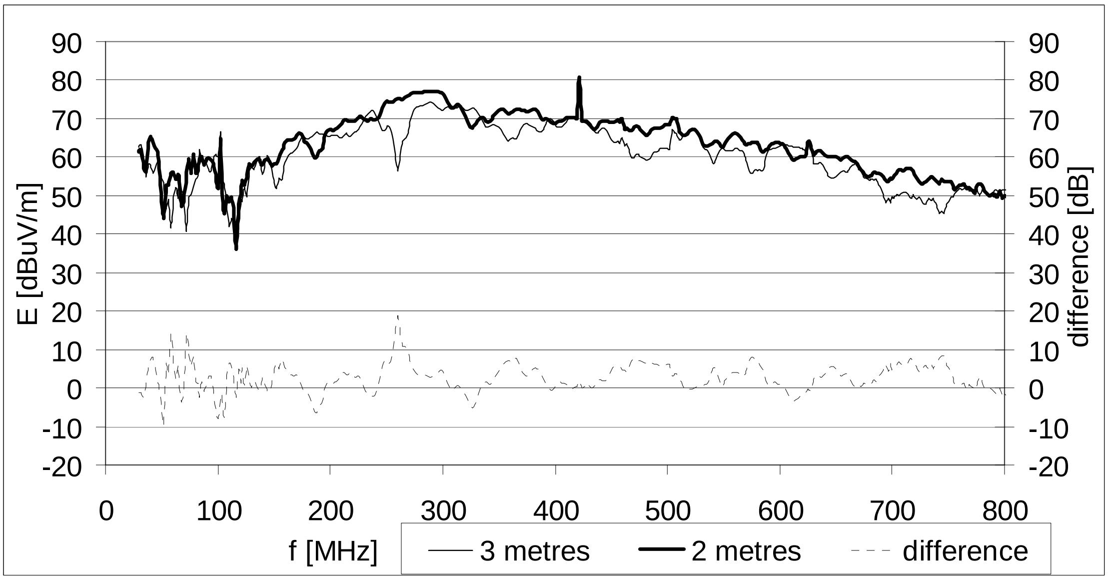

Figure 3: Shortening from 3 m to 2 m, vertical polarization.

Figure 2 and 3 show measurement results of distance shortening from 3m to 2 m in horizontal polarization. Average difference calculated from linear values is 3.02 dB for vertical and 3.15 dB for horizontal polarization. This is very close to 3.52 dB calculated by (3). Peaks in the figures 2 and 3 are caused by reflections on my test site, which is far away from ideal EMC test site.

Shortening of measurement distance is very easy type of measurement for dealing with ambients and it can be performed almost everywhere.

1.4. LINEAR SUBTRACTION OF MEASURED AND DISTURBING SIGNAL

This method is provided by some EMC receivers or by some receivers for pre-compliance testing. Method is based on assumption that during two one by one immediately done measurements the disturbing background signals are unchanged or slightly changed. Procedure is following (figure 4):

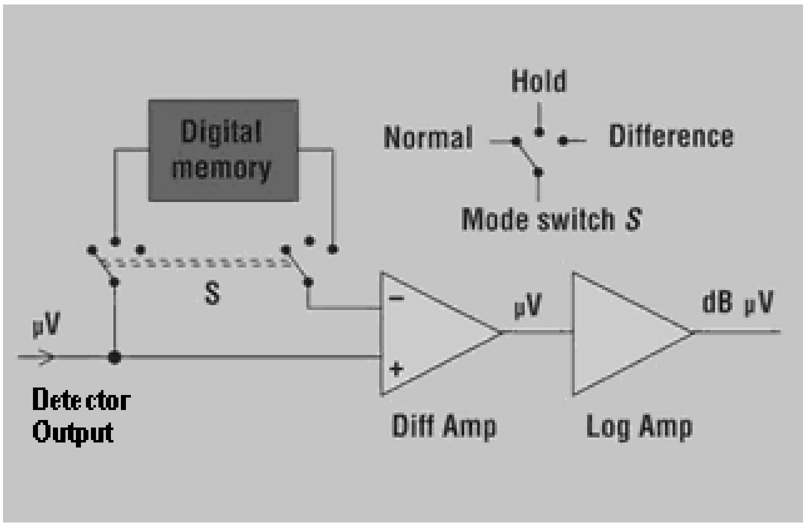

Figure 4: Principal of linear subtraction

Test site is prepared totally for measurement; EUT is on its place.

In the first step the EUT is turned off, switch *S* is in *Normal* position and ambient disturbing signals are present at the receiver input.

In the second step *S* is switched to the *Hold* position, ambients are digitized and stored in the receiver or in a PC. I use MS Excel for calculations.

In the third step EUT is turned on, switch *S* is in *Difference* position. Measured signals (EUT + ambients) and stored values are brought on the receiver input. *DiffAmp* implements subtraction of actual (EUT + ambients) and stored signal (ambients).

DiffAmp output voltage

$$U(t) = [S(t) + R_d(t)] - R_h(t), \qquad (4)$$

where *S* is disturbance from EUT

R_d is actual disturbance (*Difference* mode)

R_h is stored signal in receiver (PC) memory

And *t* is a frequency sample.

If $R_h \approx R_d$ then (indicated) voltage is practically equal to the disturbance emitted by EUT => *virtual anechoic room.*

2. CONCLUSION

Pre-compliance measurement of radiated disturbance in the presence of ambient disturbance signals is not as complicated as it seems to be. If signal from EUT is narrowband and is different from strong ambient then *Off-tuning the EMI receiver* method can be used. This method is not suitable for scanning the whole band (30 to 1000 MHz).

Signal substitution method is suitable for examining only on several frequencies because of its time demands because we are scanning frequencies separately.

Disadvantage of the *Off-tuning the EMI receiver* and *Signal substitution* method is that these methods do not work properly with modulated signals and phase shifts are not considered as well.

Method which could be combined with other procedures is the *Shortening of the measurement distance* method. We can so relatively highlight EUT signal "buried" in ambients.

For scanning the whole (wider) band is most suitable the *Linear subtraction* method because when PC software driving EMI receiver or spectrum analyzer is used we can make the whole process in about 15 to 30 minutes.

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