ASSESSMENT OF RADIO DISTURBANCE GENERATED BY AN ESTABLISHED PLC - NETWORK AT THE SWISS CITY OF FRIBOURG

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Abstract. In the year 2002 a PLC network had been installed at the Swiss city of Fribourg. With the goal to find out, if and to what extend radio services in the short wave range would be disturbed, the Swiss Federal Office of Communication (OFCOM) accomplished extensive measurements on site. The already existent man made noise at urban and rural areas has been analysed and accounted for as well. The statistical interpretation of measurement data shows, that PLC interference below 10 MHz is of little impact at urban areas because of already existent interference due to other sources. However at frequencies above 10MHz PLC interference clearly is the predominant cause for interference. Furthermore it has been shown, that the limit of the german standard NB30 is exceeded at all frequencies of interest between 2.4 MHz and 25.4 MHz at urban areas.

Introduction

The commercial application of transmission technologies at relatively high bit rates, using networks originally not designed for data transmission has led to some controversial discussions in regard to the compatibility of these systems with radio services. The main question was and still is: "Would radio reception be disturbed because of unwanted radiation generated by these systems on a local level and furthermore, would there be a degradation of radio reception for frequencies below 30 Mc on a global level". These questions concerns mainly the PLC (Power Line Communication) and ADSL (Audio Digital Subscriber Lines) technologies because these technologies would make use of networks not intentionally designed for the transmission of digital data.

In september 2002 the first commercially exploited PLC networks had been installed at different Swiss cities e.g. at the city of Fribourg, using PLC - technology of a Swiss manufacturer. With the goal to find out on site, if and to what extend radio services in the short wave range would be disturbed, the Swiss Federal Office of Communication (OFCOM) accomplished extensive measurements on site.

Applied PLC - technology

At the time being no international standard for PLC systems does exist. Consequently different manufacturers would use different frequency bands, modulation schemes and power injection ratings.

As for the PLC system applied at the city of Fribourg the data transfer is accomplished by the use of 6 distinct frequency carriers, each one representing one transmission channel of 1.5Mbits/s max. Carriers 2.4MHz, 4.8MHz and 8.4MHz are attributed to the access network (outdoor) and 19.8MHz, 22.8NHz and 25.4 MHz for indoor applications. The modulation applied: Gaussian Minimum Shift Keying (GMSK) at a bandwidth of 2MHz (–10dBc). Max. range of the transmission modems 250 meter outdoor and 100 meters indoor, extension made possible by the use of relays.

For minimum radiation power, frequency bands and the injected power are adapted continuously to traffic conditions, max. power is limited to 50mW.

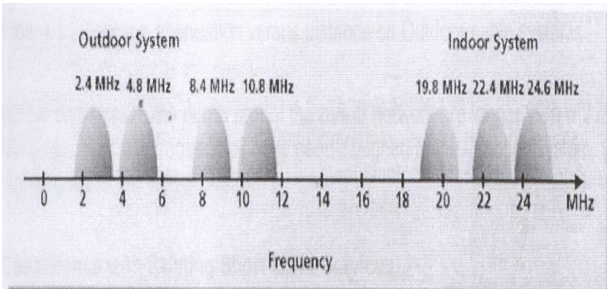

Fig. 1: Allocation of frequency bands of the PLC system applied a the City of Fribourg

Acquisition and analyses of data

The regulators (OFCOM) primary interest concerns the unwanted radiation of PLC systems at public accessible areas. The sites selected for measurement then have been exclusively at public areas (outdoors).

At urban areas man made noise is predominant. Due to the different sources of interference at those areas, it has to be noted, that resulting interference levels, do change considerably in regard of time and place.

As has been stated before, the number of channels active and the injection power of modems are constantly adapted to traffic conditions. Thus the working condition of the modems under investigation actually are not known.

For this reason and because the topology as well as the working condition of the Low Voltage network would be

different from One place to the other, it is imperative to make use of statistical methods in order to get scientifically sound results.

Classification of public accessible areas:

- places of max. PLC interference: at the ultimate proximity of modems used at data injection points to PLC cells near transformer stations (17kV/230V), called hereafter "TR- modem"
- Urban area, subdivided into industrial zones, residential zones and the very centre of the city.
- Rural area, at this area, no PLC network has been installed, the area being between 500 and 1000 meters away from the city border. Because man made noise at this area would be rather low, the earth wave generated by the nearby installed PLC network would be easily detectable.

Measurement has been taken at a total of 236 different places over a period of 6 month.

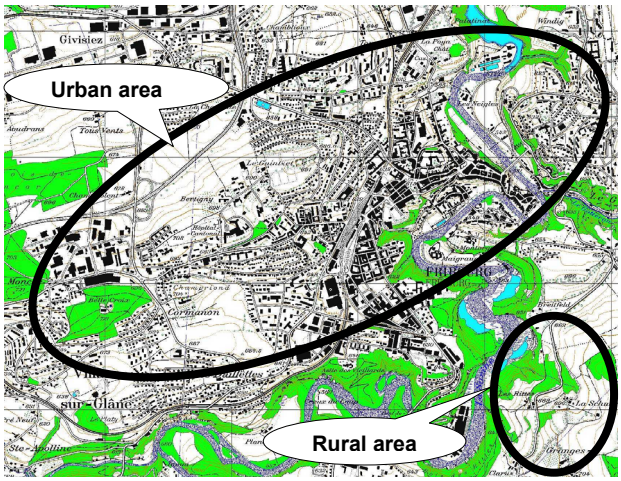

Fig. 2: City of Fribourg, typical areas of interest

The statistical treatment of measuring data at urban areas allows for the following three different analysis:

- Estimation of already existing EMI at the different frequency bands of interest (PLC coverage 0%), by an analysis of exclusively the measurement data where no PLC signal has been deductible.
- Estimation of max. possible EMI generated by completely finalised PLC network, by an analysis of exclusively the measurement data where PLC interference has been predominant.
- Estimation of actual existent EMI (at PLC coverage during the time of measurements), by an analysis of all measurement data available.

The evaluation of the interference level of PLC networks has been based on methods according to the "probability CISPR 80%" - standard. Individual measurement values represent maximum interference level at the site of measurement and the frequency band of interest

Methodology of measurement procedures

Measurements have been performed at time intervals of max. traffic density: 9-12am, 1-5pm and 7-10pm. For physical reasons EMI generated by PLC networks only can be detected if exceeding existing EMI at the places of measurement. Furthermore, for a clear identification of PLC - interference signals, an acoustical analysis was indispensable.

Parameters of measurement:

- EMI measurement only at frequency bands used of the PLC network (outdoors and indoors)
- quasi peak values, at 10kHz bandwidth (CISPR 16-1), or peak with correction factor of -6dB.
- max. value over measuring time (15 to 30s)
- time variable interference levels due to moving vehicles have not been accounted for.

A measuring receiver with an antenna according to CISPR 16 -1 has been used. At the proximity of data injection points to PLC cells, max. H-field has been searched for at a distance from the transformer housing of 3 meter and 1meter above ground according to the standard "Reg TP 322MV05".

At urban and rural areas measurement has been accomplished by the use of a special measurement car: detection of the E field component using the antenna Rhodes&Schwarz HE 011, installed 2.7 meter above ground on the top of the car. Distances to buildings (modems) have not been recorded, but they have been kept sufficient big, to guarantee far field conditions.

Results

Out of a total of 4400 individual measurements at 236 different places, 1426 values have been selected for statistics (only max values over time, channel and places of investigation). The different frequency channels have been treated separately.

Fig. 3 shows all the measurement data, selected for the statistical analysis. The minimum value lies at 6dBuV/m (rural areas) whereas the maximum value lies 75 dBuV/m (urban area). Furthermore, at urban areas the dynamic range of man made noise levels may even pass 60dB.

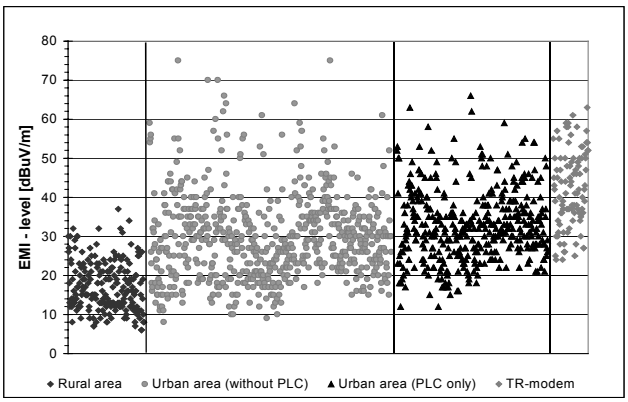

Fig. 3: Total of all measurement data selected for statistics, attributed to typical zones of interest

EMI near data injection points to PLC cells (Group of data:TR-modems)

As has been expected, max. EMI generated by PLC-networks at outdoor frequencies would be found at the ultimate proximity at data injection points to PLC cells: At 2.4MHz, the 80% value reaches 55dBuV/m. At the time intervals of interest generally 2 out of 3 channels have been active due to the relatively constant traffic density observed. Furthermore, the interference levels have been practically constant during the time intervals of interest. This leads to the assumption, that max injection power has been applied permanently.

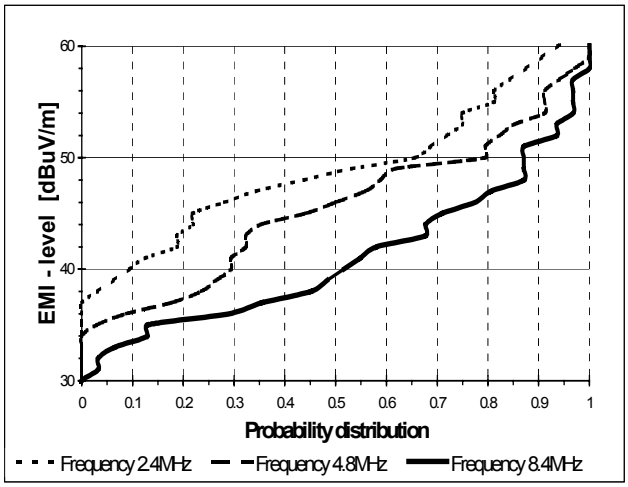

Fig. 4: Probability of interference level at PLC access network frequency – bands

EMI at urban areas

At frequencies above 10MHz, EMI generated by the PLC network clearly predominates EMI due to other sources. However at frequencies below 10MHz, as the interference level generated by other sources is accentuated, PLC interference is of little impact. The main cause for interference at urban areas and at frequencies below 10MHz are electrical buses and HV power lines.

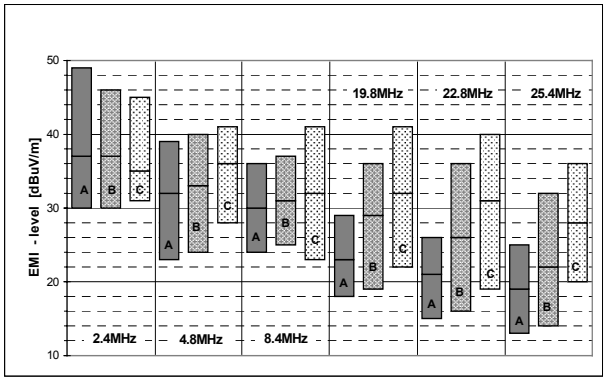

Fig. 5: EMI at urban areas (A: without PLC, B: PLC and other sources of EMI, C: PLC alone).

The top of each A-B-C diagram correspond to 80%, The bottom to 10% and the middle trace corresponds to 50% probability level.

EMI at rural areas

The measurements taken at rural areas have shown, that due to the few interfering sources, the EMI level would be relatively low. Theoretically, interference generated at this area by the PLC – network installed at the urban area would be due to ground wave propagation. In fact, no EMI generated by the PLC – network has been detected, even at the extremely low EMI level at this area.

As has been shown for urban areas, at frequencies below 10MHz, interference would be rather accentuated because of the presence of High Voltage power lines. Electrical fences of the farms around are of no statistical importance because EMI does exist only on very local level and only at certain periods of the year.

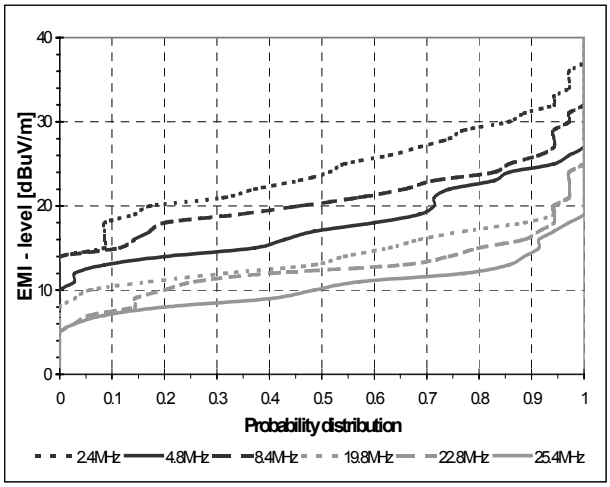

Fig. 6: EMI at PLC – frequency bands, rural area

EMI levels compared to the NB30 standard

The comparison of the results obtained on a statistical bases (CISPR 80%) indicate clearly, that EMI near TR-modems and generally at the urban area due to the PLC – network exceeds the limits of the NB30 at all frequency bands measured. However a comparison with the limits given by the standard NB30 has to be interpreted with some care because for purely practical reasons (field measurements) the exact measuring method according to the NB30 standard has not been applied rigorously. To allow for an approximate comparison, the NB30 standard has been corrected by –6dB. These correction factor is the median value obtained on a statistical basis between peak and quasi peak value during the measurement campaign

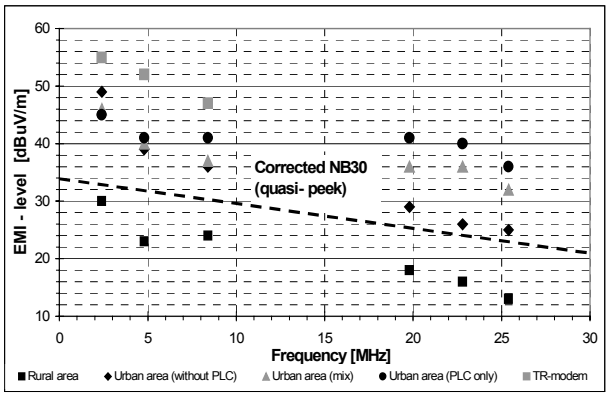

Fig. 7: Different levels of interference compared with the NB 30 standard

Quality of radio reception

Reception quality is defined by the signal-to-noise ratio (S/N) at the input of the receiver. Fig. 8 shows the degradation factor of the S/N ratio due to PLC interference at the different frequency bands, taking into account already existing EMI. According to this figure, minimum degradation occurs at urban areas at the frequency band of 2.4MHz. However the S/N ratio would be worsened up to 14dB at 4.8MHz and 22.8MHz bands, resulting to an intolerable degradation of radio reception quality.

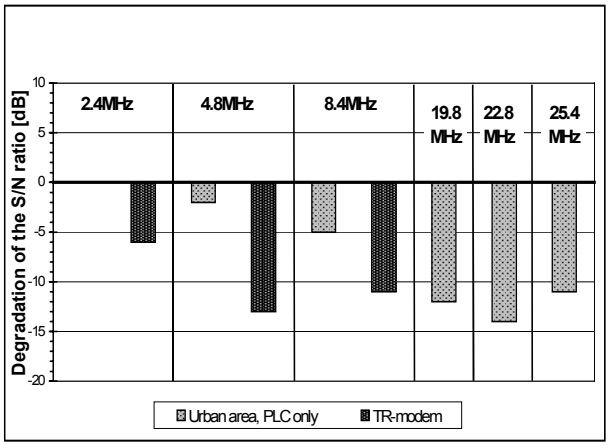

Fig. 8: Degradation factor of radio reception due to PLC interference at urban areas, based on existing EMI

Conclusion

In regard to PLC interference at urban areas of the city of Fribourg, the following conclusion may be drawn:

- At frequencies above 10MHz, EMI generated by the PLC-network clearly pre dominates EMI due to other sources. However at frequencies below 10MHz, as the interference level generated by other sources is accentuated, PLC interference would be of little impact.
- Max. interference generated by the PLC - network has been measured near modems (data injection point to PLC cells), however, it would degrade rapidly with distance.
- At urban areas, the interference level due to the PLC network and other sources of interference exceeds the german standard NB30 at all frequencies applied by the PLC network.
- The interference level (80% CISPR) of the PLC network proofed to be rather constant over the whole frequency range (about 41dBuV/m).
- At the rural area, ca. 500 meter outside the city of Fribourg, PLC interference due to the ground wave generated by the PLC network has not been detectable.

Because of the individual measurements values being spread over a wide dynamic range of 60dB, statistical methods have been applied successfully. It has to be noted however, that the results obtained are heavily dependant on the PLC technology examined and the LV network specifications (230V, Swiss standard).

References

1] M. Ianoz, "Report on the Progress concerning the use of PLC and the work in different standardization bodies", Pully, oktober 15, 2002

[2] Reg TP 322 MV 05 Part 1 , "Specification for the Measurement of Disturbance Fields from Telecommunications Systems and Networks in the Frequency Range 9kHz to 3 GHz", RegTP, october 2001

[3] ECC report on PLT,DSL, cable communications (including cable TV), LAN's and their effect on radio serves" , CEPT ECC (WG PT SE35), February 2003

[4] Recommandation UIT-R PI.372-6, "Bruit radioélectrique", 1994

[5] Recommandation UIT-R P.845-3, "Mesure du champ des ondes décamétriques", 1997

[6] Far Field Radiation study; FARFIRA Report 1-5, Ascom and Ofcom, 2001

[7] Jean-Paul van Assche und Jan Coenraads, "Information on radiaditing properties of mains network", Radiocommunications Agency Netherland, February 24, 2003

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