FortisBC Inc.
Application for a Certificate of Public Convenience and Necessity (CPCN) for the Advanced Metering Infrastructure (AMI) Project - Project No. 3698682

UNDERTAKING NO. 5

HEARING DATE: March 6, 2013

TRANSCRIPT REFERENCE: Volume 4, Page 631, Line 2 to Page 665 Line 14

REQUESTOR: David Aaron, CSTS

WITNESS: Dr. William Bailey and Dr. Yakov Shkolnikov

QUESTION: Mr. Aaron requests that Dr. Bailey provide any study reviewed for the Exponent Report that considered the long term chronic effects of the specific modulation of the AMI meter, considering that the modulation has been around for several decades.[1]

RESPONSE:

The specific modulation of the AMI meter is frequency-shift keying. Exponent has identified below studies that chronically exposed animals to the radiofrequency signals of GSM mobile phones, which use the same modulation type (frequency-shift keying). Given the limited time available, Exponent has focused its list below on GSM mobile technologies because of the following similarities to the FortisBC AMI advanced meters:

- Both technologies use the same modulation type: frequency-shift keying
- Both technologies use burst transmissions to send the signal; this change in amplitude has been of interest to Mr. Aaron's witnesses.
- Both technologies utilize frequency hopping.
- Both technologies operate in similar frequency bands.

For clarity, detailed descriptions of these terms are provided in the Appendix.

It should also be noted that there are numerous other studies of chronic exposure of animals to radiofrequency fields at other frequencies and modulations that, given the

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[1] See patent US 2,292,387 issued in 1942. First use started in the 1960s. http://www.eetimes.com/design/microwave-rf-design/4235369/A-short-history-of-spread-spectrum

parameters of the undertaking, are not included here. Some of these also have signal similarities to AMI meters.

Studies of Chronic Exposure to GSM Radiofrequency Signals (with abstract from each study)

1. **Smith P, Kuster N, Ebert S and Chevalier HJ (2007). GSM and DCS wireless communication signals: combined chronic toxicity/carcinogenicity study in the Wistar rat. Radiat Res, 168(4), 480–92.**

   Abstract

   A total of 1170 rats comprised of 65 male and 65 female Han Wistar rats per group were exposed for 2 h/day, 5 days/ week for up to 104 weeks to GSM or DCS wireless communication signals at three nominal SARs of 0.44, 1.33 and 4.0 W/kg. A preliminary study confirmed that the highest exposure level was below that which was capable of causing a measurable increase in the core temperature of the rat. Additional groups for each modulation were sham exposed, and there was also an unrestrained, unexposed (cage) control group. Fifteen male and 15 female rats per group were killed after 52 weeks. From the remaining 50 male and 50 female rats per group, surviving animals were killed after 104 weeks. Evaluations during the study included mortality rate, clinical signs, recording of palpable masses, body weight, food consumption, ophthalmoscopic examination, and clinical pathological investigations. Terminal investigations included organ weight measurement and macroscopic and microscopic pathology examinations. There was no adverse response to the wireless communication signals. In particular, there were no significant differences in the incidence of primary neoplasms, the number of rats with more than one primary neoplasm, the multiplicity and latency of neoplasms, the number of rats with metastases, and the number of benign and malignant neoplasms between the rats exposed to wireless communication signals and rats that were sham exposed.

2. Tillmann T, Ernst H, Ebert S, Kuster N, Behnke W, Rittinghausen S and Dasenbrock C (2007). Carcinogenicity study of GSM and DCS wireless communication signals in B6C3F1 mice. Bioelectromagnetics, 28(3), 173–87.

Abstract

The purpose of this study using a total of 1170 B6C3F1 mice was to detect and evaluate possible carcinogenic effects in mice exposed to radio-frequency-radiation (RFR) from Global System for Mobile Communication (GSM) and Digital Personal Communications System (DCS) handsets as emitted by handsets operating in the center of the communication band, that is, at 902 MHz (GSM) and 1747 MHz (DCS). Restrained mice were exposed for 2 h per day, 5 days per week over a period of 2 years to three different whole-body averaged specific absorption rate (SAR) levels of 0.4, 1.3, 4.0 mW/g bw (SAR), or were sham exposed. Regarding the organ-related tumor incidence, pairwise Fisher's test did not show any significant increase in the incidence of any particular tumor type in the RF exposed groups as compared to the sham exposed group. Interestingly, while the incidences of hepatocellular carcinomas were similar in EMF and sham exposed groups, in both studies the incidences of liver adenomas in males decreased with increasing dose levels; the incidences in the high dose groups were statistically significantly different from those in the sham exposed groups. Comparison to published tumor rates in untreated mice revealed that the observed tumor rates were within the range of historical control data. In conclusion, the present study produced no evidence that the exposure of male and female B6C3F1 mice to wireless GSM and DCS radio frequency signals at a whole body absorption rate of up to 4.0 W/kg resulted in any adverse health effect or had any cumulative influence on the incidence or severity of neoplastic and non-neoplastic background lesions, and thus the study did not provide any evidence of RF possessing a carcinogenic potential.

Studies of Chronic Exposure to Other Burst Transmission Radiofrequency Signals (with abstract from each study)

3. Bartsch H, Küpper H, Scheurlen U, Deerberg F, Seebald E, Dietz K, et al (2010). Effect of chronic exposure to a GSM-like signal (mobile phone) on survival of female Sprague-Dawley rats: modulatory effects by month of birth and possibly stage of the solar cycle. Neuro Endocrinol Lett, 31(4), 457–73.

Abstract

During 1997-2008 two long-term (I and II) and two life-long (III and IV) experiments were performed analyzing the effect of chronic exposure to a low-intensity GSM-like signal (900 MHz pulsed with 217 Hz, 100 µW/cm² average power flux density, 38-80 mW/kg mean specific absorption rate for whole body) on health and survival of unrestrained female Sprague-Dawley rats kept under identical conditions. Radiofrequency (RF)-exposure was started at 52-70 days of age and continued for 24 (I), 17 (II) and up to 36 and 37 months, respectively (III/IV). In the first two experiments (1997-2000) 12 exposed and 12 sham-exposed animals each were observed until they were maximally 770 or 580 days old. In experiment I no adverse health effects of chronic RF-exposure were detectable, neither by macroscopic nor detailed microscopic pathological examinations. Also in experiment II no apparent macroscopic pathological changes due to treatment were apparent. Median survival time could not be estimated since in none of the groups more than 50% of the animals had died. In the course of two complete survival experiments (2002-2005; 2005-2008) 30 RF- and 30 sham-exposed animals each were followed up until their natural end or when they became moribund and had to be euthanized. A synoptical data analysis was performed. Survival data of all four groups could be fitted well by the Weibull distribution. According to this analysis median survival was significantly shortened under RF-exposure in both experiments by 9.06% (95% CI 2.7 to 15.0%) (p=0.0064); i.e by 72 days in experiment III and 77 days in experiment IV as compared to the corresponding sham-treated animals (III: 799 days; IV: 852 days). Both groups of animals of experiment III showed reduced median survival times by 6.25% (95% CI -0.3 to 12.4%) (p=0.0604) compared to the corresponding groups of experiment IV (53 days: sham-exposed animals, 48 days: RF-exposed animals) which may be due to the fact that animals of experiment III were born in October and animals of experiment IV in May

indicating that the month of birth affects life span. From the results of the last two experiments it has to be concluded that chronic exposure to a low-intensity GSM-like signal may exert negative health effects and shorten survival if treatment is applied sufficiently long and the observational period covers the full life span of the animals concerned. The current data show that survival of rats kept under controlled laboratory conditions varies within certain limits depending on the month of birth. In view of our previous observations regarding an inhibitory or no effect of RF-exposure on DMBA-induced mammary cancer during the 1997-2000 period, an additional modulatory influence on a year-to-year basis should be considered which might be related to changing solar activity during the the 11-years' sunspot cycle. These potentially complex influences of the natural environment modulating the effects of anthropogenic RF-signals on health and survival require a systematic continuation of such experiments throughout solar cycle 24 which started in 2009.

4. Oberto G, Rolfo K, Yu P, Carbonatto M, Peano S, Kuster N, Ebert S, Tofani S. Carcinogenicity study of 217 Hz pulsed 900 MHz electromagnetic fields in Pim1 transgenic mice. Radiat Res. 2007 Sep;168(3):316-26.

Abstract

In an 18-month carcinogenicity study, Pim1 transgenic mice were exposed to pulsed 900 MHz (pulse width: 0.577 ms; pulse repetition rate: 217 Hz) radiofrequency (RF) radiation at a whole-body specific absorption rate (SAR) of 0.5, 1.4 or 4.0 W/kg [uncertainty (k = 2): 2.6 dB; lifetime variation (k = 1): 1.2 dB]. A total of 500 mice, 50 per sex per group, were exposed, sham-exposed or used as cage controls. The experiment was an extension of a previously published study in female Pim1 transgenic mice conducted by Repacholi et al. (Radiat. Res. 147, 631-640, 1997) that reported a significant increase in lymphomas after exposure to the same 900 MHz RF signal. Animals were exposed for 1 h/day, 7 days/week in plastic tubes similar to those used in inhalation studies to obtain well-defined uniform exposure. The study was conducted blind. The highest exposure level (4 W/kg) used in this study resulted in organ-averaged SARs that are above the peak spatial SAR limits allowed by the ICNIRP (International Commission on Non-ionizing Radiation Protection) standard for environmental exposures. The whole-body average was about three times greater than the highest average SAR reported in the earlier study by Repacholi et al. The results of this study do not suggest any effect of 217 Hz-pulsed RF-radiation exposure

(pulse width: 0.577 ms) on the incidence of tumors at any site, and thus the findings of Repacholi et al. were not confirmed. Overall, the study shows no effect of RF radiation under the conditions used on the incidence of any neoplastic or non-neoplastic lesion, and thus the study does not provide evidence that RF radiation possesses carcinogenic potential.

5. **Repacholi MH, Basten A, Gebski V, Noonan D, Finnie J, Harris AW. Lymphomas in E mu-Pim1 transgenic mice exposed to pulsed 900 MHZ electromagnetic fields. Radiat Res. 1997 May;147(5):631-40.**

Abstract

Whether radiofrequency (RF) fields are carcinogenic is controversial; epidemiological data have been inconclusive and animal tests limited. The aim of the present study was to determine whether long-term exposure to pulse-modulated RF fields similar to those used in digital mobile telecommunications would increase the incidence of lymphoma in E mu-Pim1 transgenic mice, which are moderately predisposed to develop lymphoma spontaneously. One hundred female E mu-Pim1 mice were sham-exposed and 101 were exposed for two 30-min periods per day for up to 18 months to plane-wave fields of 900 MHz with a pulse repetition frequency of 217 Hz and a pulse width of 0.6 ms. Incident power densities were 2.6-13 W/m2 and specific absorption rates were 0.008-4.2 W/kg, averaging 0.13-1.4 W/kg. Lymphoma risk was found to be significantly higher in the exposed mice than in the controls (OR = 2.4. P = 0.006, 95% CI = 1.3-4.5). Follicular lymphomas were the major contributor to the increased tumor incidence. Thus long-term intermittent exposure to RF fields can enhance the probability that mice carrying a lymphomagenic oncogene will develop lymphomas. We suggest that such genetically cancer-prone mice provide an experimental system for more detailed assessment of dose-response relationships for risk of cancer after RF-field exposure.

6. Sommer AM, Streckert J, Bitz AK, Hansen VW, Lerchl A. No effects of GSM-modulated 900 MHz electromagnetic fields on survival rate and spontaneous development of lymphoma in female AKR/J mice. BMC Cancer. 2004 Nov 11;4:77

Abstract

BACKGROUND: Several reports indicated that non-thermal electromagnetic radiation such as from mobile phones and base stations may promote cancer. Therefore, it was investigated experimentally, whether 900 MHz electromagnetic field exposure influences lymphoma development in a mouse strain that is genetically predisposed to this disease. The AKR/J mice genome carries the AK-virus, which leads within one year to spontaneous development of thymic lymphoblastic lymphoma.

METHODS: 320 unrestrained female mice were sham-exposed or exposed (each n = 160 animals) to GSM like 900 MHz electromagnetic fields for 24 hours per day, 7 days per week, at an average whole body specific absorption rate (SAR) value of 0.4 W/kg. Animals were visually checked daily and were weighed and palpated weekly. Starting with an age of 6 months, blood samples were taken monthly from the tail. Animals with signs of disease or with an age of about 46 weeks were sacrificed and a gross necropsy was performed.

RESULTS: Electromagnetic field exposure had a significant effect on body weight gain, with higher values in exposed than in sham-exposed animals. However, survival rate and lymphoma incidence did not differ between exposed and sham-exposed mice.

7. **Adey WR, Byus CV, Cain CD, Higgins RJ, Jones RA, Kean CJ, Kuster N, MacMurray A, Stagg RB, Zimmerman G, Phillips JL, Haggren W. Spontaneous and nitrosourea-induced primary tumors of the central nervous system in Fischer 344 rats chronically exposed to 836 MHz modulated microwaves. Radiat Res. 1999 Sep;152(3):293-302.**

Abstract
We have tested an 836.55 MHz field with North American Digital Cellular (NADC) modulation in a 2-year animal bioassay that included fetal exposure. In offspring of pregnant Fischer 344 rats, we tested both spontaneous tumorigenicity and the incidence of induced central nervous system (CNS) tumors after a single dose of the carcinogen ethylnitrosourea (ENU) in utero, followed by intermittent digital-phone field exposure for 24 months. Far-field exposures began on gestational day 19 and continued until weaning at age 21 days. Near-field exposures began at 35 days and continued for the next 22 months, 4 consecutive days weekly, 2 h/day. SAR levels simulated localized peak brain exposures of a cell phone user. Of the 236 original rats, 182 (77%) survived to the termination of the whole experiment and were sacrificed at age 709-712 days. The 54 rats (23%) that died during the study ("preterm rats") formed a separate group for some statistical analyses. There was no evidence of tumorigenic effects in the CNS from exposure to the TDMA field. However, some evidence of tumor-inhibiting effects of TDMA exposure was apparent. Overall, the TDMA field-exposed animals exhibited trends toward a reduced incidence of spontaneous CNS tumors ($P < 0.16$, two-tailed) and ENU-induced CNS tumors ($P < 0.16$, two-tailed). In preterm rats, where primary neural tumors were determined to be the cause of death, fields decreased the incidence of ENU-induced tumors ($P < 0.03$, two-tailed). We discuss a possible approach to evaluating with greater certainty the possible inhibitory effects of TDMA-field exposure on tumorigenesis in the CNS.

8. **Repacholi MH, Basten A, Gebski V, Noonan D, Finnie J, Harris AW. Lymphomas in E mu-Pim1 transgenic mice exposed to pulsed 900 MHZ electromagnetic fields. Radiat Res. 1997 May;147(5):631-40.**

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Appendix

The FortisBC AMI smart meter utilizes burst transmissions of frequency hopping spread spectrum (FHSS), frequency-shift keying (FKS) modulated signal to transmit data. The following sections explain these different terms.

Burst transmission

Burst transmission is defined as a transmission that combines a very high data signaling rate with very short transmission times.[2]

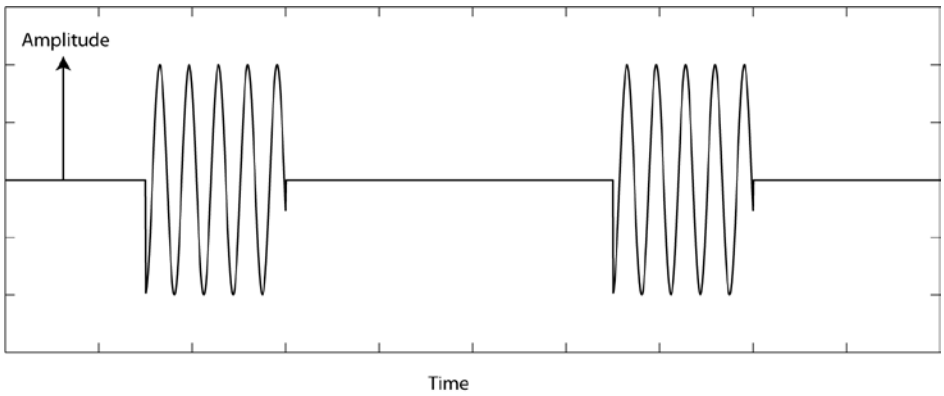

Figure 1. Burst transmission: Characteristic of FortisBC AMI smart meters, DECT cordless phones and baby monitors, GSM phones, CDMA phones (when in standby), microwave ovens (at less than 100% power), Wi-Fi, and Bluetooth.

Jumps in amplitude that accompany burst transmissions serve a different purpose than pulse-amplitude modulated (PAM) transmission.[3] In PAM, the amplitude of the amplitude-modulated pulses conveys the *information*. In burst transmission, the amplitude of the bursts does not convey information and just serves the function of reducing power consumption or channel utilization.

[2] http://www.its.bldrdoc.gov/fs-1037/dir-006/_0751.htm
[3] http://www.its.bldrdoc.gov/fs-1037/dir-029/_4233.htm

Frequency-shift keying (FSK)

Frequency-shift keying is defined as a frequency modulation in which the modulating signal shifts the output frequency between predetermined values.[4]

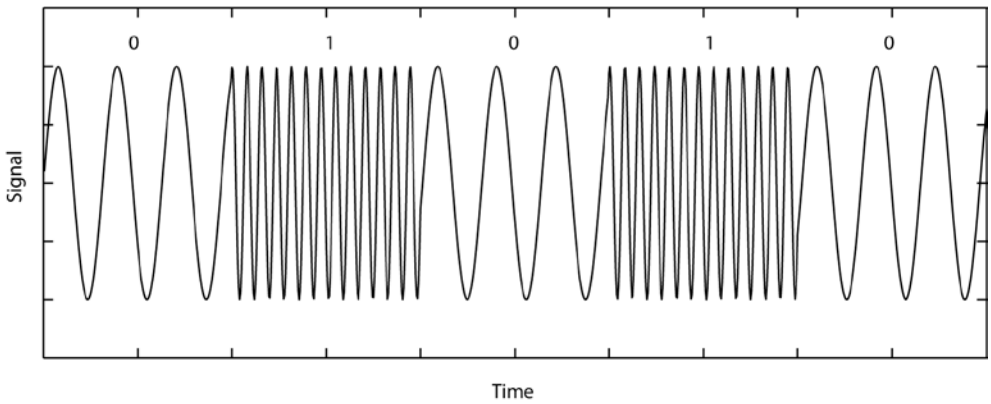

Figure 2. Frequency-shift keying modulation transmission of a bit sequence: 0 1 0 1 0. FSK is utilized by FortisBC AMI smart meters, DECT cordless phones and baby monitors, GSM phones, older Wi-Fi, and Bluetooth.

In a FSK modulated systems, the amplitude of the signal does not depend on the information transmitted; only the frequency is varied.

[4] http://www.its.bldrdoc.gov/fs-1037/dir-016/_2347.htm

Burst transmission of FSK-modulated signal

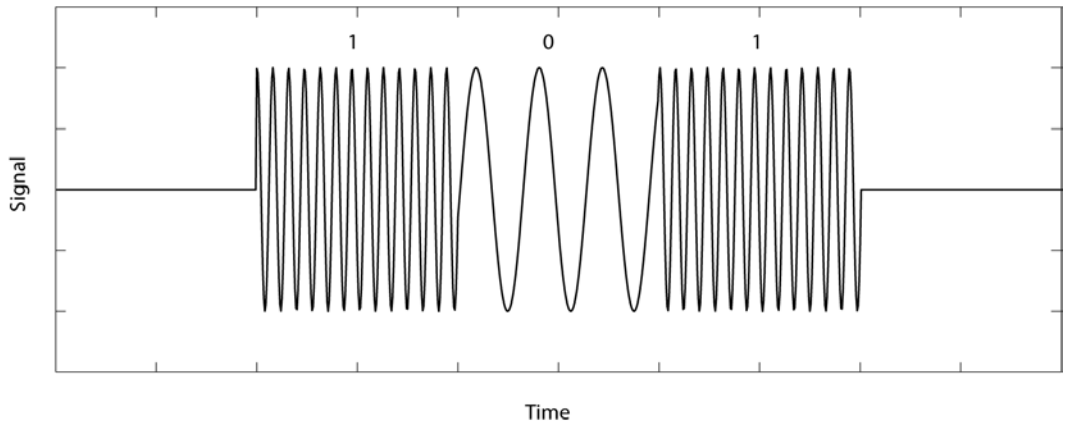

Figure 3. Burst transmission of frequency-shift keying modulated signal for a bit sequence: 1 0 1. This combination of burst transmissions of FSK modulated signal is a characteristic of FortisBC AMI smart meters, DECT cordless phones and baby monitors, GSM phones, older Wi-Fi, and Bluetooth.

Frequency hopping

Frequency hopping is defined as the "repeated switching of [carrier] frequencies during radio transmission according to a specified algorithm."[5]

[5] http://www.its.bldrdoc.gov/fs-1037/dir-016/_2373.htm

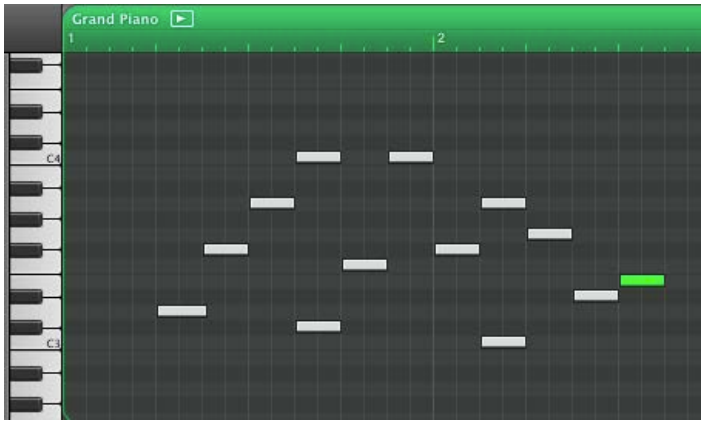

Figure 4. Piano roll analogy for frequency hopping. The carrier frequency switches between discrete set of frequencies as a function of time.

The selection of the carrier frequencies is typically made in a pseudo-random manner from a set of frequencies to be transmitted.[6] Frequency hopping is utilized by FortisBC AMI smart meters, GSM phones,[7] older Wi-Fi routers, and Bluetooth. When frequency hopping is used for purposes of allowing several devices to reuse the frequencies, frequency hopping is referred to as frequency-hopping spread spectrum (FHSS).

Similarities between GSM phone and FortisBC AMI smart meter

As described above, the FortisBC AMI smart meter utilizes burst transmissions of the FHSS FKS modulated signal to send the data.

A GSM phone uses burst transmissions of frequency hopping (FH)-FSK modulated signal to send the data. The difference between frequency hopping utilized by a GSM phone and FHSS such as used by the FortisBC AMI smart meter is minor and is not relevant for purposes of our comparison. FHSS terminology is utilized when describing communication systems which allow frequency reuse. Frequency hopping terminology is utilized when such

[6] http://www.its.bldrdoc.gov/fs-1037/dir-016/_2346.htm
[7] http://www0.cs.ucl.ac.uk/staff/t.pagtzis/wireless/gsm/radio.html

frequency reuse is not utilized. Therefore, there is no practical difference between FHSS-FSK and FH-FSK communication systems for purposes of this discussion.

Moreover, both GSM phones and FortisBC AMI smart meters utilize similar communication frequencies. GSM phones use 850 MHz, 900 MHz, 1800 MHz, and 1900 MHz bands depending on the nation and generation of deployment. FortisBC AMI smart meters utilize the 900 MHz band.