Human volunteer studies: general and special populations.

Human Exposure to Base Station Signals
Source Specification

Introduction

This document provides an outline specification for the exposure source that will be used by the research group funded by the MTHR programme to perform a provocation study investigating the basis of symptoms attributed by a volunteer group to their exposure to base station emissions.

Exposure Conditions

The typical power densities of such base station signals are described in NRPB Report R321 (reference below), and it is also noted that signals from other transmitters can give comparable contributions to a person's total exposure. For this reason, exposure and testing of the study subjects must take place in an experimental facility where the power density of signals from base stations, as well as from other transmitters, is controlled.

http://www.nrpb.org/publications/archive/reports/2000/nrpb_r321.htm

NRPB found that the typical power densities of individual GSM base station signals at locations where people were concerned about their exposure were generally in the range 10 µW m^{-2} to 1 mW m^{-2}, however typical maximum exposures approached 10 mW m^{-2}. It is therefore proposed to use signals with a power density of around 10 mW m^{-2} in this study.

Test Environment

It is likely that an electromagnetically enclosed environment will have to be used for the experiment in order to control externally arising radio signals, however it may be possible to verify that other environments are sufficiently "quiet". A semi-anechoic chamber would be an ideal environment and would place constraints on the exposure distance between a base station source and an exposed subject.

Assuming a chamber length of 10 m would imply that an exposure distance of around 5 m would be used in the experiment. A source EIRP (Effective Isotropic Radiated Power, the power × gain product) of around 3 W would therefore give rise to the required power density.

Source Requirements

A micro GSM base station would be able to act as a transmitting source for use in the study. Such a base station would consist of an antenna, together with radio transmitters and controller electronics.

The micro base station would have to be modified to transmit autonomously, i.e. without the need to receive any incoming radio signals from mobile phones or be networked with any external systems.

The software of the micro base station would have to be modified so that it can transmit simulated GSM base station carriers according to the specification below. In view of this, the support of industry will be required to provide the base station, modify its software and provide technical support to the research team.

The antenna of the micro base station should be of a low-gain type in order to produce a wide beam for uniform exposure of subjects within a few metres. To provide the required EIRP, it should contain 2 W transmitters, although it may be necessary to reduce this maximum power to suit the precise experimental conditions. Two transmitters would be required for the reasons in the next section.

Transmitted Signals

The variations in the power of base station signals over time is described in the appendix to this specification. Two different types of signal can be produced, each with different time-domain characteristics. In order for the exposure in this experiment to be realistic, it will therefore be necessary to transmit both types of signal from the base station, one from each of its transmitters.

Transmitter 1 should produce a signal equivalent to that containing the Broadcast Control Channel (Logical BCCH) from normal base stations. This signal should have full power bursts contained in every timeslot. It should also include periods of constant power signal to represent the frequency correction channel.

Transmitter 2 should produce a signal equivalent to those containing only traffic channels (Logical TCH) from normal base stations. This signal should have partial occupancy of its time-slots and variable power levels within the time-slots. Some form of repeated, but typical sequence could be used for this.

Simon Mann, NRPB
10 October 2002

Background Note on GSM Base Station Signals

The variation in the power GSM base station signals over time is described in Section 2.2.3 of NRPB Report R321, which can be obtained through the link in the main document. This appendix provides further explanation and also includes measured data.

Timing of Signals

The longest duration structure in the GSM base station signal that this project need be concerned with is the 120 ms multiframe. This contains 26 frames, which in turn contain 8 timeslots. The signal timing is summarised in the following table.

Name of structure	Contains	Duration
Hyperframe	1024 superframes	626.88 s
Superframe	51 multiframes	6.12 s
Multiframe	26 frames	120 ms
Frame	8 timeslots	4.615 ms
Timeslot	156.24 symbols	576.9 µs
Symbol		3.692 µs

Table 1 Time-domain structure of GSM radio carriers

The modulation scheme used with GSM is known as gaussian minimal shift keying (GMSK). It is a phase modulation scheme in which the modulation symbols are either –90° or +90° transitions, depending on the data stream. Each symbol carries one bit of data and so the modulated data rate is 270.1 kbit s^{-1}.

BCCH Carriers

A portion of BCCH carrier is shown in Figure 1. This shows how the waveform power drops briefly to zero at the time-slot boundaries, which occur every 576.9 µs. This is because each timeslot contains a separately formed burst, whose power ramps up and down during the timeslot.

The radio carrier containing the broadcast control channel (denoted BCCH in the spreadsheet) always has a full power burst in every timeslot and cannot use adaptive power control.

Figure 2 shows the data from Figure 1 on a more finely resolved time-axis, although it should be noted that the spectrum analyser used could not sample quickly enough to follow the power variations occurring at the symbol rate. The sampling interval was 14.6 µs, whereas on longer than around 1.5 µs would have been required to properly follow the power variations.

Frequency correction bursts are transmitted from time to time and these appear as ~4.5 ms periods when pure sinusoids are transmitted and the power variations at the symbol rate cease, as shown in Figure 3.

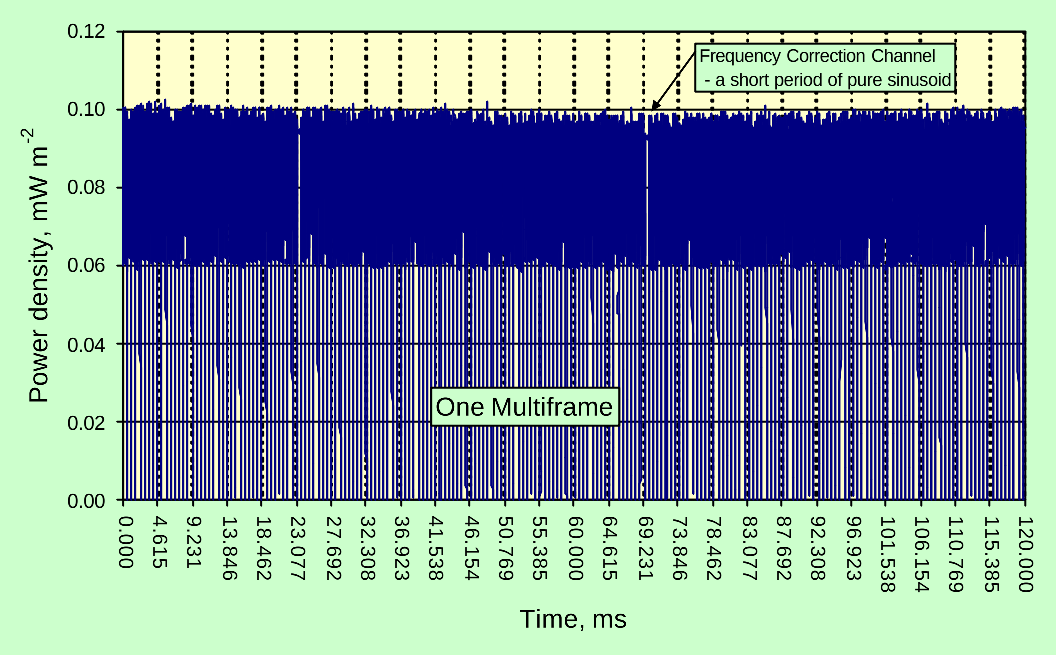

Figure 1 Power variations in the BCCH carrier from a GSM base station over a period of 1 multiframe.

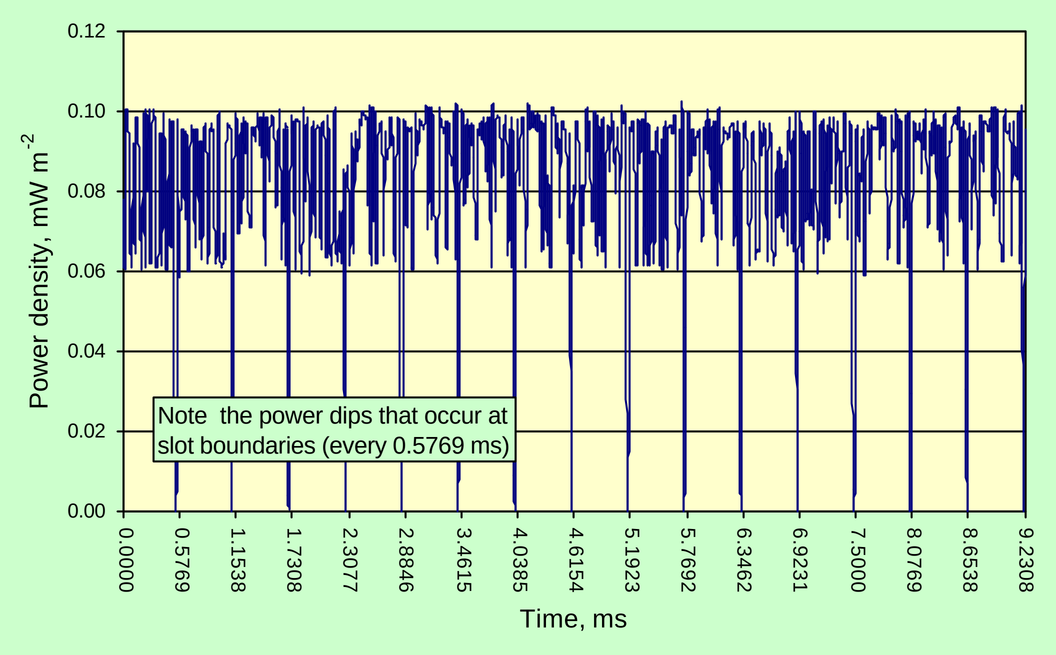

Figure 2 Power variations in the BCCH carrier from a GSM base station over two frames (16 timeslots).

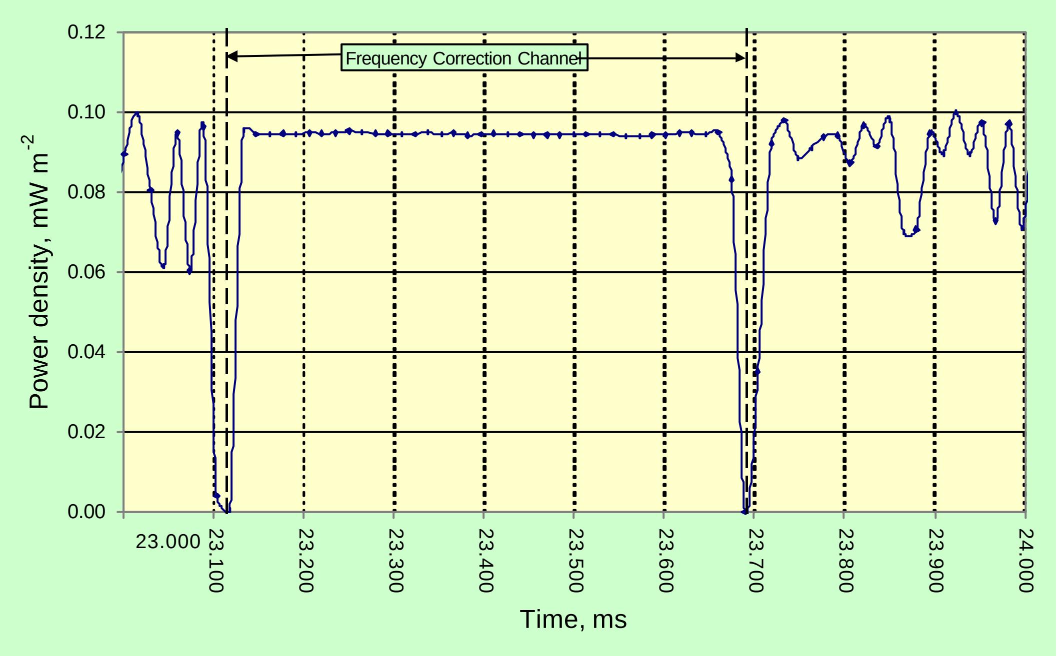

Figure 3 Power variations in the BCCH carrier from a GSM base station showing the constant power level during the frequency correction burst.

TCH Carriers

Carriers from base stations aside from the BCCH carrier have partial slot occupancy, according to the load conditions on the base station. Different base stations have different numbers of transmitters and although there is always 1 BCCH carrier, there may be several TCH carriers. Large macrocellular base stations can produce 10 or more.

Figure 4 and Figure 5 and show the power variation of a typical TCH carrier over time. Since each timeslot is allocated to a particular mobile phone user, the appropriate power level is used for that user. Also, if a timeslot is not allocated to a mobile phone, no burst is emitted. The adaptive power control used with TCH carriers allows the power of bursts to vary downwards in a sequence of 2 dB steps from the BCCH maximum.

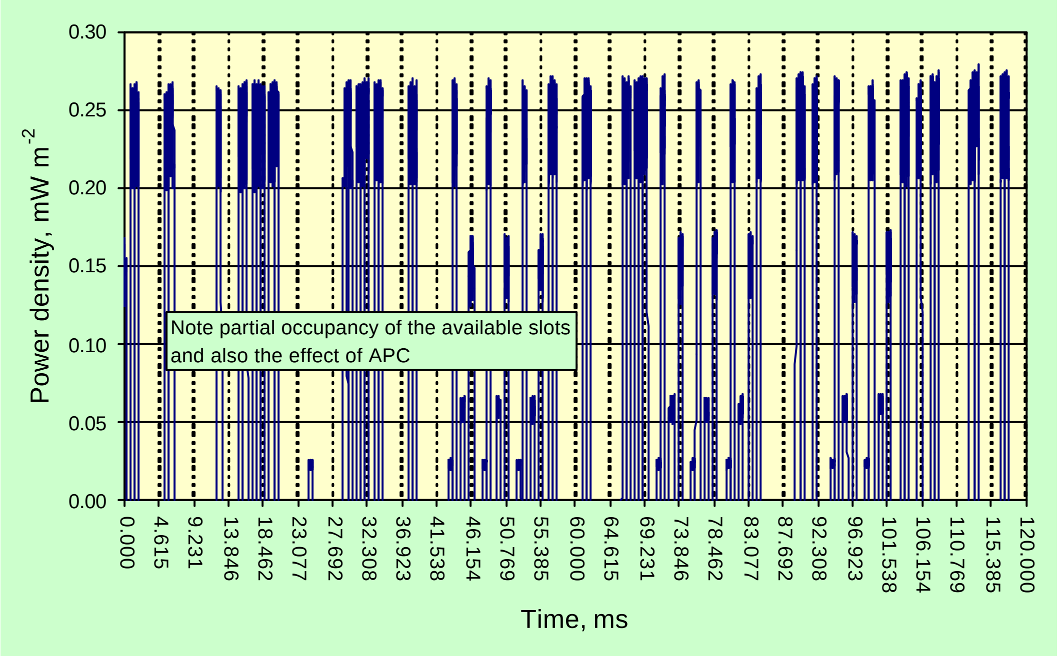

Figure 4 Power variations in the TCH carrier from a GSM base station over a period of 1 multiframe.

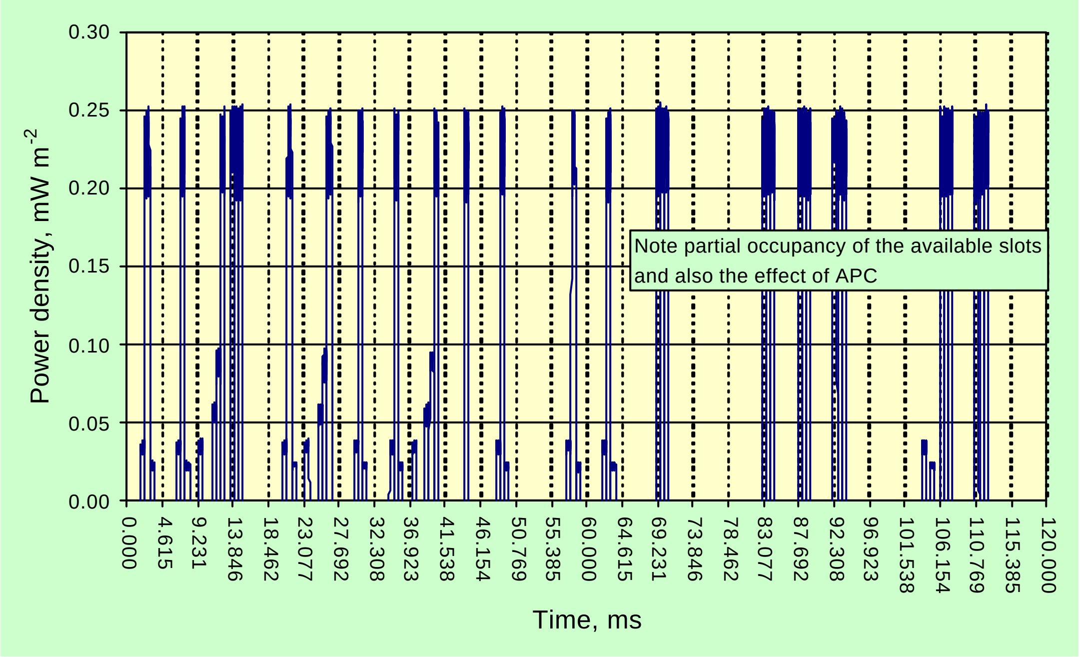

Figure 5 Power variations in the TCH carrier from a GSM base station over a period of 1 multiframe.