Using the Spectrum Analyzer as an Educational Tool for Mobile Communications

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Abstract

Application of the spectrum analyzer for illustrating several concepts associated with mobile communications is discussed. Specifically, two groups of observable features are described. First, time variation and frequency selectivity of multipath propagation can be revealed by carrying out simple measurements on commercial-network GSM and UMTS signals. Second, the main time-domain and frequency-domain features of GSM and UMTS radio signals can be observed. This constitutes a valuable tool for teaching mobile communication courses.

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1 Introduction, setting and required equipment

Mobile communication courses require the students to grasp certain concepts that are abstract and often difficult to visualize. It is thus desirable for the teacher to provide a means to illustrate those concepts in a more concrete way. In this paper, use of the spectrum analyzer is described to achieve these goals in two specific areas:

- Illustration of multipath propagation effects; and
- Observation of the time and frequency structure of actual signals.

The spectrum analyzer is a relatively affordable instrument which is usually available for radio communication courses. Although normally employed for representing frequency spectra, it can also be utilized for time-domain observations.

There are two ways in which the spectrum analyzer can be used for the intended purposes:

- Practical laboratory work done by the students under supervision; or
- Classroom demonstrations carried out by the teacher.

The former has the advantage of greater student involvement and more direct contact with the measurements. Classroom demonstrations, on the other hand, give the teacher more control; in this case student involvement can be achieved, to a certain extent, by means of questions and discussions guided by the teacher. Both options have been successfully applied by the author in mobile communication courses within Telecommunication Engineering degrees, at Universidad Autónoma de Madrid (2005–2009) and at Universidad Politécnica de Madrid (2010 to present date).

The following equipment is needed for the measurements:

- Spectrum analyzer with frequency range up to 2.5 GHz; resolution bandwidth down to a few kHz; possibility to set zero frequency span; sweep time down to 5 ms, or better 1 ms; trace averaging capability. Basic models usually fulfill these requirements amply.

  If classroom demonstrations are to be done, the analyzer should allow connecting to a laptop computer for projecting the measurements on the classroom screen; and should preferably be of the portable type.

- Antenna: it can be easily built by attaching a rigid wire to the inner conductor at one end of a coaxial cable.

- Laptop computer with appropriate software for connecting with the instrument, in the case of classroom demonstrations.

Sections 2 and 3 respectively describe the two kinds of measurements referred to at the outset.

2 Propagation effects on GSM and UMTS signals

A salient feature of propagation in mobile communications is the existence of multiple paths. This phenomenon gives rise to time-varying and frequency-selective *fading*, i.e. time and frequency variations in the received signal power [1]. These two types of variations can be easily observed with a spectrum analyzer. They are dealt with separately in the following.

2.1 Time variations

The time variation of a channel is characterized by its *coherence time*. This is defined as the minimum time separation necessary to observe a significant change in the channel response, and corresponds to a displacement of a fraction of the wavelength, λ, by the mobile; typically $\lambda/2$ is considered as a reference.

The standard way to measure time variations in attenuation would be to transmit a sinusoidal wave and observe the received power. For greater realism, and to avoid use of a signal generator, signals transmitted from actual networks can be used. The two main candidate systems are currently GSM and UMTS[1]. The former is preferred for this measurement because of its small bandwidth, on the order of 200 kHz, which is lower than the coherence bandwidth of most propagation channels. A UMTS signal, with its 4-MHz bandwidth, could easily experience frequency-selective fading, and the consequent frequency diversity would result in smaller variations of the total received power.

A requirement on the transmitted signal is that it should have constant power, so that the received power accurately reflects variations in channel attenuation. This is easily accomplished by using a GSM *beacon* carrier[2]. These are special carriers that are transmitted with fixed power, except for guard intervals (further details are given below and in Section 3.2).

In order to observe time variations in received signal power, the analyzer frequency span needs to be set to zero. This way, the horizontal axis in the graph directly represents time, instead of frequency. Using a sweep time of several seconds, time variations can easily be observed as the receiving antenna is moved. It is best to use single-sweep mode, so that the trace remains on screen after the measurement.

Resolution bandwidth can be set to a value slightly larger than the GSM signal bandwidth, such as 300 kHz. Alternatively, since the signal's power spectral den-

[1]All physical-layer features and propagation aspects of GSM signals to be observed apply also to the GSM-evolved technologies known as GPRS and EDGE. Similarly, the discussion of UMTS signals is equally applicable to HSDPA and HSUPA. Thus, throughout the paper, the terms "GSM" and "UMTS" should be interpreted in this broader sense, that is, as "GPRS/GPRS/EDGE" and "UMTS/HSDPA/HSUPA" respectively.

[2]The usual convention is followed in this paper, whereby a GSM signal transmitted on a given frequency is called a "carrier", even though it is a modulated signal and thus not strictly a carrier.

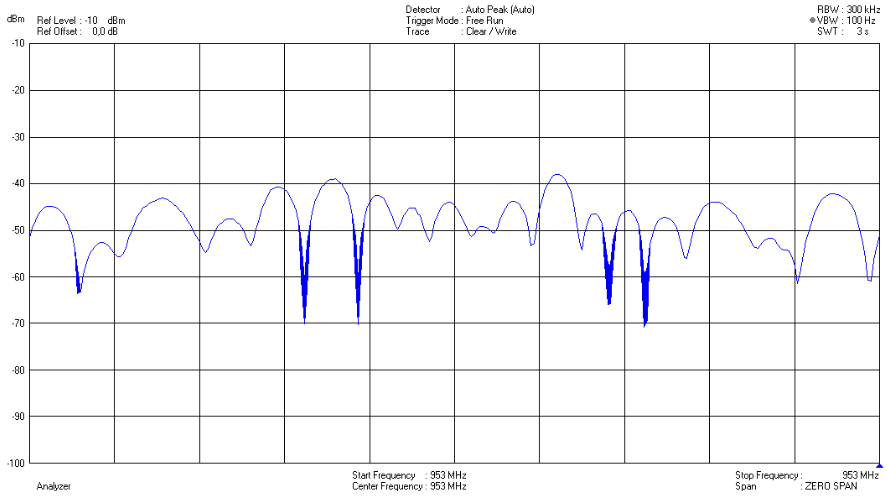


Figure 1: Time-varying fading, GSM beacon carrier, 900-MHz band

sity is highest at the center frequency, a lower resolution bandwidth can be applied to reduce the noise perceived in the representation. If the average received signal level is good a 300-kHz bandwidth is recommended, as in this case the vertical axis can be directly interpreted as total received power of the GSM signal.

The burst nature of the GSM signal needs to be taken into account when selecting video bandwidth. Specifically, the signal is organized into 0.547-ms bursts separated by 30.5-μs guard intervals (see Section 3.2). Since the received power suddenly drops during guard intervals, whose duration is much smaller than the sweep time, the unfiltered received power displayed on the screen would take the form of a band, reflecting the fast variations associated with the alternating bursts and guard intervals. The video bandwidth should be sufficiently small to remove this effect. However, too small a value would affect the power variations caused by fading, and thus must be avoided. A value of 100 Hz has been found to be adequate.

Several beacon carriers will typically be received at the measurement spot. Ideally the strongest one should be selected, so that the margin of powers that can be measured (which is limited by the noise power at the used resolution bandwidth) be as large as possible. The selection can be done by a quick analysis of the desired frequency band. Section 3.2 discusses how to distinguish beacon from non-beacon carriers.

Figure 1 shows the variations in received power from a beacon carrier in the 900-MHz band, in an indoor environment. During each measurement, which consists of a single sweep of 3 s, the antenna is moved at an approximate speed of 1 m/s. The familiar multipath fading pattern is observed, with steep minima and milder maxima (this is actually an artifact of the logarithmic scale), and with variations of 20–30 dB.

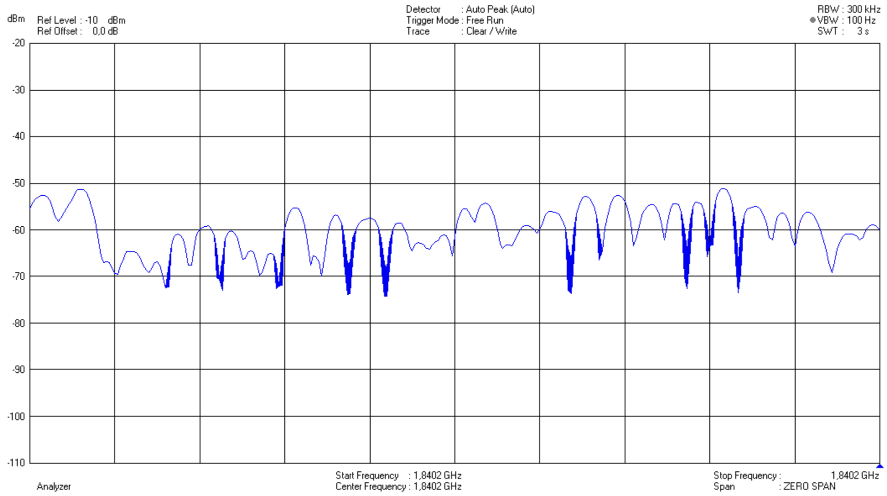


Figure 2: Time-varying fading, GSM beacon carrier, 1800-MHz band

It can be checked that a significant variation in signal power corresponds to a displacement on the order of $\lambda/2$. In this case λ is approximately 0.3 m, represented by one horizontal division. Figure 2 is similar except that a beacon carrier in the 1800-MHz band is used, which gives twice as fast variations.

2.2 Frequency selectivity

Frequency selectivity of a channel is measured by its *coherence bandwidth*, defined as the minimum separation of two frequencies that experience significantly different attenuations. In order to observe frequency-selective fading, a wideband signal is required, with a bandwidth comparable or greater than the coherence bandwidth of the channel.

GSM signal GSM signals very rarely experience frequency-selective fading, because coherence bandwidths are usually much larger than 200 kHz. This can be illustrated by placing the antenna at various positions, and observing how the spectrum on the screen moves up and down coherently, i.e. all frequency components experience the same fading, and no distortion occurs.

In order to obtain a cleaner representation, trace averaging can be applied in the analyzer. In this case, however, the fading variations as the antenna is moved cannot be observed so easily, because it takes some time (depending on the averaging procedure; typically a few seconds) for the representation to settle after the antenna position has been changed.

Figure 3 shows an example measurement with trace averaging. The GSM signal spectrum is undistorted, as corresponds to flat fading.

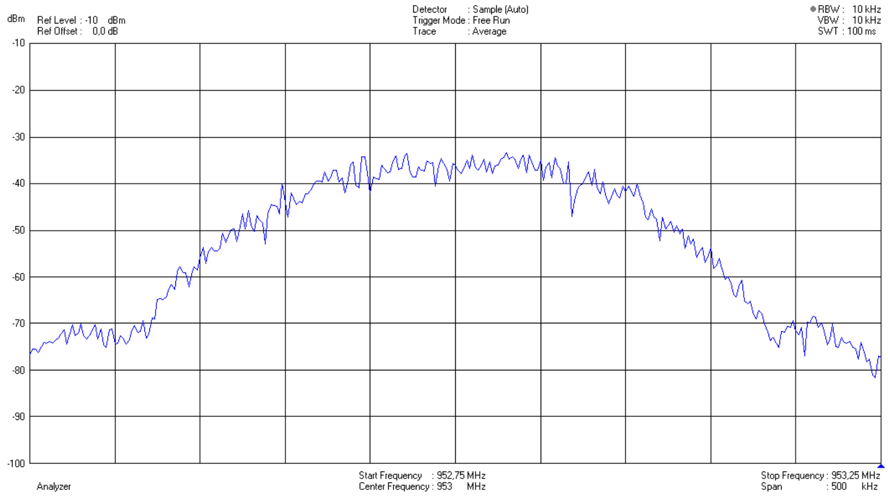


Figure 3: Frequency-flat fading, GSM signal

UMTS signal The situation is different with UMTS signals, whose 4-MHz bandwidth is usually enough to make frequency selectivity apparent. Due to larger signal bandwidth and lower power spectral density values compared to GSM, trace averaging is indispensable in this case.

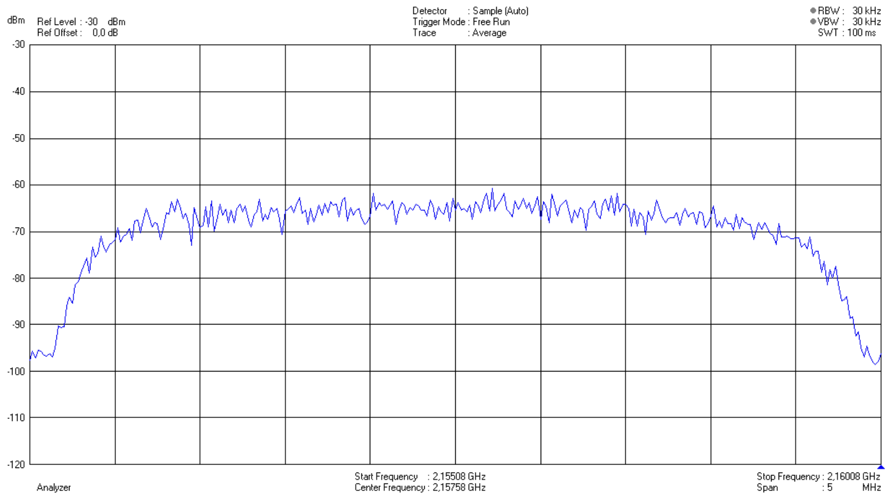
Testing several antenna locations, it is easy to find some where the signal spectrum is approximately flat, while at others frequency-selective fading is clearly noticeable. Figure 4(a) is an example of the former, while Figure 4(b) illustrates the latter, showing (linear) distortion on the spectrum. The measurement can also provide a rough approximation of the coherence bandwidth of the channel.

3 Time-domain and frequency-domain characteristics of GSM and UMTS signals

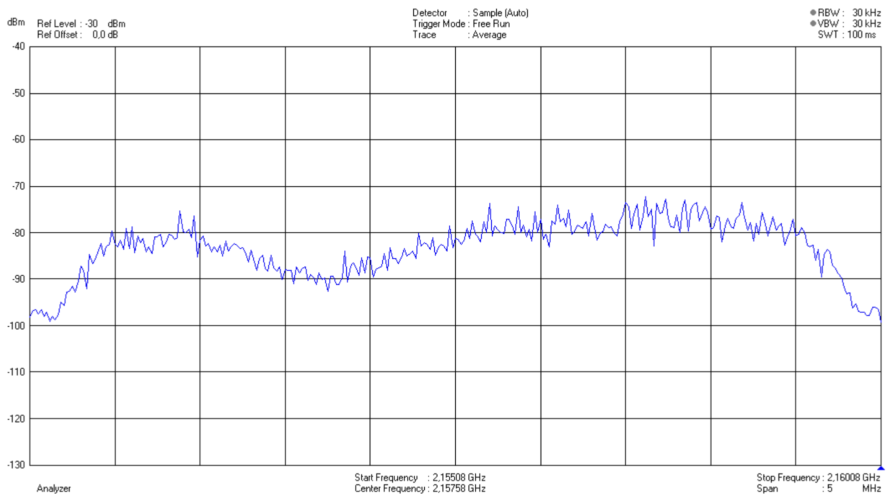
As is well known, GSM is an FDMA/TDMA system, whereas UMTS is an FDMA/DS-CDMA system [1]. The spectrum analyzer can be used to observe time-domain and frequency-domain, but not code-domain, characteristics of signals. Consequently, both types of features can be observed in GSM signals, whereas only frequency aspects can be revealed in UMTS signals. In the following, frequency aspects of these signals are dealt with first, and then the time structure of GSM signals is discussed.

3.1 Frequency-domain features of GSM and UMTS signals

Observation of the spectra of these signals is rather straightforward. Examples can be seen in Figures 3 and 4(a) above. In addition, specific parameters can be



(a) No observed frequency-selective fading



(b) Frequency-selective fading clearly visible

Figure 4: Frequency-selective fading, UMTS signal

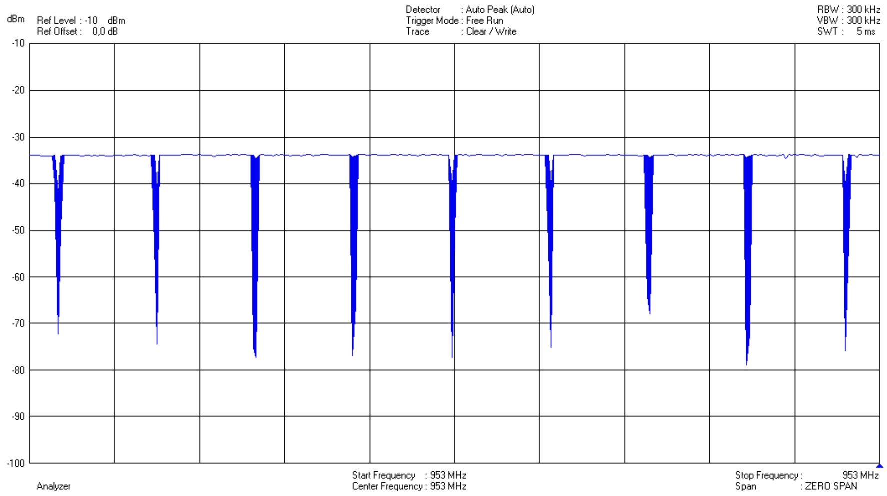


Figure 5: Frame in a GSM beacon carrier

measured such as total received signal power, adjacent channel power ratio, or occupied bandwidth for a given percentage of signal power.

3.2 Time-domain features of GSM signals

GSM signals are organized into *frames* of period $T_\mathrm{f} = 4.615$ ms, each consisting of 8 *time-slots*. A time-slot is occupied with a *burst* that lasts $T_\mathrm{b} = 0.547$ ms followed by a *guard interval* of $T_\mathrm{g} = 30.5$ μs [2]. GSM carriers can be classified into beacon or non-beacon. In a beacon carrier, time-slots without traffic are filled with “dummy” bursts, so that some transmitted signal is always present; and transmitted power is constant, i.e. no power control is permitted. These two features allow the mobiles to utilize beacon carriers for attenuation measurements (this is the reason why beacon carriers were used in Section 2.1).

Time-slot and frame structure The frame structure of GSM signals can be revealed using a similar approach as that used in Section 2.1; that is, setting zero frequency span, resolution bandwidth of 300 kHz and single-sweep mode, in order to inspect the instantaneous power variations of the signal. The video bandwidth is not critical, and can be left equal to the resolution bandwidth. Using a sweep time on the order of T_f, frames and slots can be identified in the signal. Figure 5 shows an example graph for a beacon carrier. A lower sweep time allows a closer examination of bursts and guard intervals, as shown by Figure 6. Their duration can be approximately measured from the graph (sweep time is 1 ms).

Repeating the procedure with a non-beacon carrier gives the result in Figure 7. The distinctive non-beacon features can be seen: some time-slots are empty (owing to absence of traffic); and power levels vary (owing to power control). This

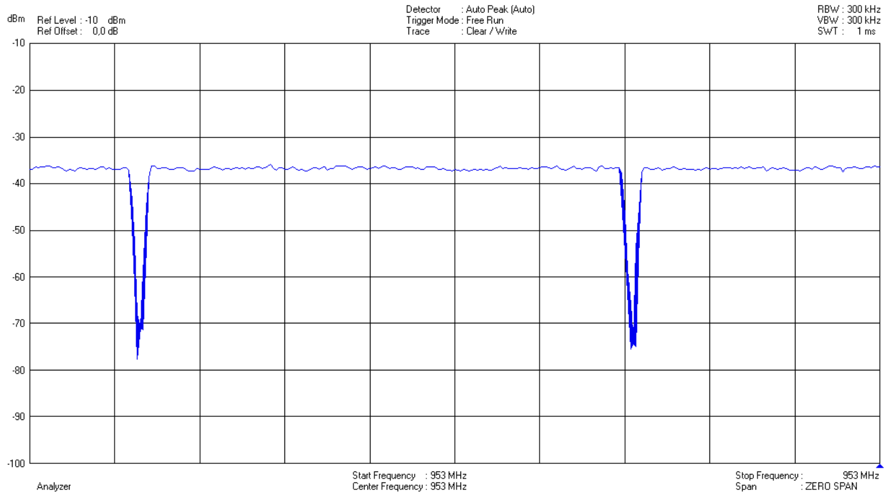


Figure 6: Time-slots in a GSM beacon carrier

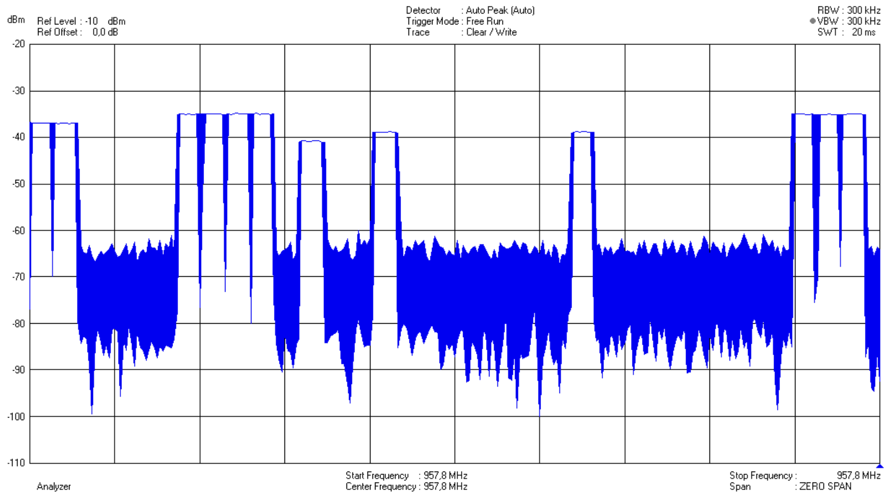


Figure 7: Frames in a GSM non-beacon carrier

may be used to raise some issues with the students and motivate discussion. For example, it may be asked why the empty time-slots are not the same in consecutive frames.

It should be added that even in a frequency-domain view of all signals present in a GSM band, beacon and non-beacon carriers can be distinguished. Non-beacon carriers tend to flicker, that is, they appear or disappear according to whether a burst is present or not when its spectral position is swept by the analyzer. Beacon carriers are stable, and usually have higher power, due to the absence of power control.

FCCH channel structure GSM base stations transmit a special channel known as FCCH (frequency-correction channel), which consists of sinusoidal bursts of known frequency, and is used by the mobiles as a frequency and time reference. The FCCH is present on the first time-slot of certain frames of each beacon carrier (this is another distinctive feature of beacon carriers). As happens with every channel in GSM, the FCCH shares its time-slot with other channels by time-multiplexing, following a *multiframe* structure. For this channel, the applicable multiframes (there are two different versions) have a period of 51 frames, numbered from 0 to 50; and FCCH occurs in frames 0, 10, 20, 30 and 40 [2]. This gives a time separation of 10 or 11 frames between consecutive FCCH bursts, depending on their location within the multiframe.

The FCCH bursts have all their bits equal to 0. With the differential binary GMSK modulation used in GSM, this results in a sinusoidal burst with frequency value $f_0 + R/4$, where f_0 is the carrier frequency and $R = 270.833$ kb/s is the bit rate. This simple structure permits the mobile to easily detect this channel (in fact, it is the first channel that a GSM mobile should search for). Likewise, it allows for its observation on a spectrum analyzer, as follows. Since the FCCH consists of bursts of frequency $R/4 = 67.7$ kHz above the carrier frequency, and is the only channel with that feature, its appearances can be detected using zero frequency span, single sweep, and a filter with very low resolution bandwidth centered at the indicated frequency. Each FCCH burst will produce a higher output level than any other channel's bursts. A sweep time slightly larger than $51T_\mathrm{f} = 235.4$ ms should be used, so that five consecutive FCCH bursts can be detected.

Figure 8 shows an example graph with a resolution bandwidth of 3 kHz (this is the minimum value allowed by the spectrum analyzer used). The highest peaks in the trace correspond to FCCH bursts. It can be seen that the first four bursts have a time separation of approximately $10T_\mathrm{f} = 46.2$ ms, whereas the separation between the fourth and the fifth is approximately equal to $11T_\mathrm{f} = 50.8$ ms (a horizontal division corresponds to 25 ms).

4 Conclusion

Use of the spectrum analyzer has been discussed for illustrating time-domain and frequency-domain aspects of multipath propagation and of the structure of radio signals in current mobile communication systems.

Appendix: example of laboratory handout

An example laboratory handout (in Spanish) along the lines described in this paper is provided at the end of this paper.

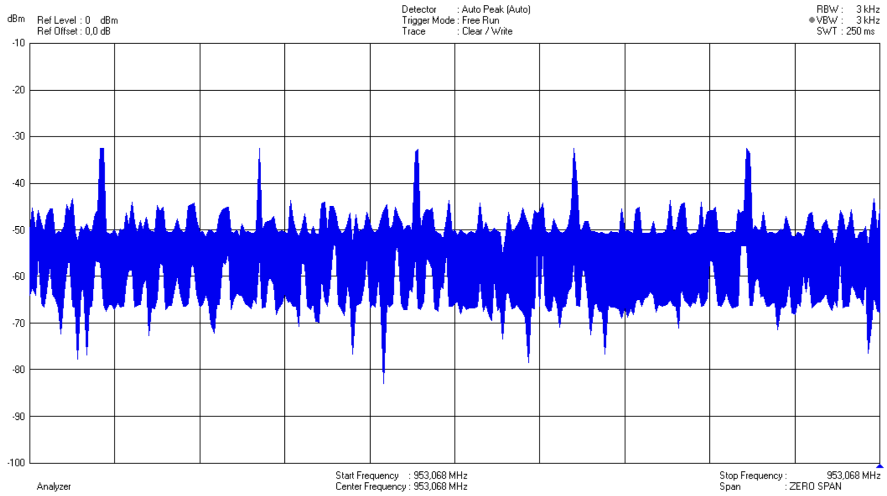


Figure 8: FCCH multiframe structure (GSM beacon carrier)

Acknowledgement

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References

[1] J. M. Hernando, *Comunicaciones Móviles*, 2nd ed. Centro de Estudios Ramón Areces, 2004.

[2] M. Mouly and M.-B. Pautet, *The GSM System for Mobile Communications*. Published by the authors, 1992.

Comunicaciones Móviles

Práctica de laboratorio: analizador de espectros

Índice

1. Introducción

En esta práctica se observan señales GSM y UMTS mediante el analizador de espectros, y se estudian algunas de sus características. Para ello se utilizarán señales de las redes de comunicaciones móviles existentes, recibidas mediante una antena.

A lo largo de la práctica se plantean preguntas relacionadas con el trabajo realizado. Estas preguntas se indican mediante letra cursiva. Tras la realización de la práctica deberá entregarse una pequeña memoria que contenga las respuestas a dichas preguntas, así como cualquier otro comentario que considere relevante.

2. Señal GSM

2.1. Observación en el dominio de la frecuencia

Encienda el analizador de espectros y conecte la antena a la entrada RF INPUT 50 Ω. Pulse PRESET para llevar el analizador al estado predefinido por defecto.

Seleccione como banda de frecuencia de observación la banda descendente de GSM 900, comprendida entre 935 y 960 MHz (FREQ|Start, Stop). Utilice para ello las teclas numéricas y de unidades. Para separar bien las señales, fije el ancho de banda de resolución en modo manual (BW|Res BW manual) y elija 30 kHz (el ancho de banda de una señal GSM es del orden de 200 kHz). Para ello puede utilizar las teclas $\Uparrow$ y $\Downarrow$. Observará varias señales, cada una de las cuales corresponde a una portadora del sistema GSM. Pruebe a cambiar la frecuencia central (FREQ|Center) o el barrido de frecuencia (SPAN), y observe el efecto sobre la representación. Para variar la frecuencia central puede ser más cómodo utilizar la rueda. Para configurar el paso de frecuencia central aplicado al girar la rueda utilice FREQ|CF-Stepsize. Seleccione la frecuencia central correspondiente a algunas de las portadoras y reduzca el barrido de frecuencia, de modo que pueda ver bien cada una de las señales. Observará que en algunas la representación se mantiene estable, mientras que en otras la traza fluctúa. *¿A qué es debido?*

Localice una señal que se mantenga estable y reduzca el barrido de frecuencia a 1 MHz. Compruebe que el tiempo de barrido esté configurado en modo automático (SWEEP|Sweeptime Auto) y el ancho de banda de resolución en modo manual (BW|Res BW manual). Reduzca progresivamente el ancho de banda de resolución (tecla $\Downarrow$). *Observe y razone el efecto sobre la representación y sobre el tiempo de barrido.*

Fije el ancho de banda de resolución en 10 kHz, y observe la señal recibida para diferentes posiciones de la antena. *¿A qué se deben las variaciones de nivel de señal? ¿Observa desvanecimiento selectivo en frecuencia? ¿Qué puede decir sobre el ancho de banda de coherencia del canal?*

2.2. Medidas sobre el espectro

Seleccione los siguientes parámetros de medida: frecuencia central $948{,}8$ MHz, barrido de frecuencia 500 kHz, tiempo de barrido automático, ancho de banda de resolución 30 kHz. Para obtener una representación más suave, utilice el modo de representación de traza promediado (TRACE|Trace mode|Average), y elija un número de muestras (Sweep Count) en torno a 500.

A continuación se va a determinar el ancho de banda de la señal a 10 dB. Disminuya la escala del eje vertical (AMPT|Range Log) a 50 dB, y ajuste adecuadamente el nivel de referencia Ref Level para ver la parte superior de la señal. Para observar el punto que se encuentra x dB por debajo del nivel máximo de la señal se utilizan dos marcadores, de la siguiente forma. Pulse la tecla MKR, con lo cual aparecerá un marcador. Sitúe el marcador en la frecuencia de la portadora, $948{,}8$ MHz (mediante teclas numéricas y de unidades, o bien girando la rueda). Active un segundo marcador mediante Marker 2. Este segundo marcador aparecerá por defecto con la opción Delta, para medir diferencias de frecuencia y de nivel respecto al primer marcador. Mueva el segundo marcador hasta localizar el punto a 10 dB por debajo del primero a cada lado, y lea la separación de frecuencia (parte superior derecha de la pantalla). *¿Cuánto vale el ancho de banda a 10 dB?*

Mida el ancho de banda al $99\,\%$ de potencia, mediante MEAS|More |OBW| % Power Bandwidth. Determine, probando diferentes porcentajes de potencia, la proporción de potencia contenida en un ancho de banda de 200 kHz. *Indique y comente los resultados de estas medidas.*

La relación de potencia en los canales adyacentes se define como la potencia contenida en un intervalo de 200 kHz en torno a la portadora entre la potencia radiada en un intervalo contiguo del mismo tamaño. Para medir esta relación, defina mediante MEAS|CP, ACP, MC-ACP|CP/ACP Config:

- # of TX Chan: 1;
- # of Adj Chan: 1;
- Channel Settings|Channel bandwidth|Tx: 200 kHz (teclas numéricas y de unidades, ENTER, ESC); ADJ: 200 kHz;
- Channel Settings|Channel Spacing|Tx: 200 kHz, ADJ: 200 kHz.

Realice la medida con el mismo ancho de banda de resolución anterior (30 kHz) y con promediado de traza. Observe la potencia en el canal deseado (intervalo de 200 kHz en torno a la portadora) y la relación de potencia de los canales adyacentes. *¿Qué valor toma la potencia en el canal deseado? Compare la relación de potencia en los canales adyacentes con los resultados de la medida anterior de porcentaje de potencia contenida en* 200 *kHz. ¿Son coherentes?*

2.3. Observación en el dominio del tiempo

Seguidamente se va a observar la señal de $948{,}8$ MHz en el dominio del tiempo. Para ello seleccione:

- Modo de representación de traza normal, es decir, sin aplicar promediado (TRACE|Trace mode|Clear write; Sweep Count con valor 1).
- Frecuencia central $948{,}8$ MHz.

- Barrido de frecuencia cero (SPAN|Zero Span). De esta forma la frecuencia de observación no varía a lo largo del barrido, con lo que el eje horizontal actúa como eje de tiempo.

- Ancho de banda de resolución de 300 kHz, de modo que toda la señal esté contenida dentro del filtro.

- Tiempo de barrido (SWEEP|Sweeptime Manual) de 10 ms, comparable al periodo de trama de GSM.

- Barrido único (Single Sweep). El analizador realiza un único barrido y deja la traza fija. Para realizar un nuevo barrido, pulse Continue Single Sweep.

Interprete la representación obtenida. ¿Que parámetro temporal de la señal GSM puede medirse? Modifique el tiempo de barrido si es necesario, y mida el valor de este parámetro. Para ello, utilice un marcador "normal" (MKR) y otro "delta" (Marker 2). Sitúe el primer marcador en un mínimo relativo de la señal (MKR →|More|Min; o muévalo a mano) y el segundo en el siguiente mínimo (Select: 2, Next Min Mode: "<" o ">", Min, Next Min; o muévalo a mano). Calcule el valor teórico correspondiente (tenga en cuenta que en GSM el periodo de trama es $120/26 = 4{,}615$ ms). *¿Coinciden los valores teórico y medido?*

Teniendo en cuenta el ancho de banda de resolución utilizado, *¿cómo se puede medir la potencia de la señal en esta representación? ¿Coincide con los valores medidos anteriormente?*.

Compruebe, utilizando un ancho de banda de resolución de 10 kHz y un barrido de frecuencia de 1 MHz, la existencia de una señal centrada en 952,8 MHz. *¿Qué diferencias observa respecto a la señal centrada en 948,8 MHz?*

A continuación se va a observar en el dominio del tiempo la señal centrada en 952,8 MHz. Utilice para ello dicho valor de frecuencia central, barrido de frecuencia cero, ancho de banda de resolución de 300 kHz y barrido único de duración 50 ms. Realice varios barridos (Continue Single Sweep) y observe la forma de la señal. Reduzca el tiempo de barrido y compare con la representación que obtuvo para la señal anterior (948,8 MHz). *¿Qué diferencias observa? ¿Es constante en el tiempo la potencia de señal? ¿Se aprecia alguna periodicidad en la señal? ¿Por qué? ¿Puede asegurar que alguna de las dos señales corresponde a una portadora baliza? ¿Puede asegurar que alguna de las dos no corresponde a una baliza?*

2.4. Observación del canal FCCH dentro de la multitrama de 51 tramas

En este apartado se va a observar el canal FCCH. Este canal consiste en una ráfaga de 148 bits iguales a 0, y se transmite en el intervalo 0 de las portadoras baliza de GSM, con una periodicidad marcada por la estructura de la multitrama de 51 tramas, según se indica en el apéndice A.

La modulación de GSM equivale a una modulación de frecuencia binaria diferencial mediante pulsos gaussianos, con una desviación de frecuencia $\pm R/4$, siendo $R = 270{,}833$ kb/s la velocidad binaria en la interfaz radio. Para cada periodo de bit, la desviación de frecuencia aplicada es positiva cuando el valor del bit es igual al del periodo anterior, y negativa en caso contrario.

Localice una portadora baliza con un nivel de potencia elevado. Calcule la frecuencia de la ráfaga del FCCH para la portadora utilizada, y fije los siguientes parámetros en el analizador:

- Frecuencia central igual al valor calculado.
- Barrido de frecuencia cero.
- Ancho de banda de resolución de 3 kHz, con objeto de aislar la ráfaga del FCCH.
- Tiempo de barrido (SWEEP|Sweeptime Manual) de 250 ms, para ver una multitrama completa.
- Barrido único.

Compruebe la existencia de varios picos, que corresponden a las ráfagas del canal FCCH. Mida la separación temporal entre los picos, buscando con un marcador normal y un marcador "delta" dos máximos consecutivos de la señal representada (MKR $\rightarrow$|Peak, (Select: 2, Next Peak; o moviendo directamente con la rueda). *¿Cuántos valores diferentes se obtienen, y cuáles son dichos valores?. ¿Coinciden las separaciones temporales obtenidas con las marcadas por la estructura de la multitrama?*

En la representación se apreciarán otros picos de menor nivel. Para observar mejor su situación temporal puede utilizar el sincronismo de barrido, de la siguiente forma. Fije en primer lugar barrido continuo (SWEEP|Continuous Sweep) de duración $92{,}308$ ms, es decir, 20 periodos de trama. De este modo cada trama se corresponderá con media división horizontal en la pantalla. Seleccione a continuación sincronismo basado en la señal de vídeo (TRIG|Trg/Gate Source|Video), y sitúe el nivel de disparo (Trg/Gate Level) en un valor adecuado para que coincida con los picos del FCCH. Tenga en cuenta lo siguiente:

- La traza no se actualiza si no se supera el nivel de disparo seleccionado.
- Con el nivel de sincronismo correctamente seleccionado, el primer pico aparece en el extremo izquierdo de la pantalla. Para verlo mejor aplique un desplazamiento temporal (Trigger Offset) de $-9{,}231$ ms (dos tramas, o una división horizontal).

Utilice el modo de representación de traza de valor máximo (TRACE|Trace Mode|Max Hold) para mantener los picos en la pantalla. *¿Cuál puede ser la razón de que aparezcan estos picos de menor nivel?*

3. Señal UMTS

3.1. Observación en el dominio de la frecuencia

Restaure el analizador a su estado predefinido (PRESET), y observe la banda descendente del modo FDD de UMTS, comprendida entre 2110 MHz y 2170 MHz. Busque la señal más potente dentro de la banda, y visualícela con un barrido de frecuencia de 10 MHz (el ancho de banda de una señal UMTS es aproximadamente 4 MHz). Ajuste el ancho de banda de resolución para ver la señal lo más claramente posible. Puede ser necesario utilizar promediado de traza.

3.2. Medidas sobre el espectro

Mida la potencia de la señal recibida, con un ancho de banda de resolución de 30 kHz. El procedimiento es similar al ya utilizado para GSM. Para definir más rápidamente los parámetros de la medida, seleccione directamente el estándar utilizado (MEAS|CP, ACP, MC-AC|CP/ACP Standard), que es el W-CDMA 3GPP FWD (enlace descendente de UMTS). *Compare la medida de potencia con la que se obtuvo para GSM.*

¿Cuál de las dos señales (GSM y UMTS) es más difícil de detectar? ¿A qué es debido?

En UMTS se transmiten radiocanales a diferentes frecuencias, con una separación de 5 MHz. *¿Tiene sentido en este caso medir la potencia de la señal en los canales adyacentes (como se hizo en GSM)?*

3.3. Estimación del ancho de banda de coherencia del canal

Observe la señal recibida para diferentes posiciones de la antena. Si utiliza promediado de traza, tenga en cuenta que la representación tiene cierta memoria o inercia. *¿Qué puede decir sobre el ancho de banda de coherencia del canal?*

Apéndice A Multitrama de 51 tramas en GSM

A continuación se representan las tres versiones que existen de la multitrama de 51 tramas en GSM. Cada casilla representa una trama, dentro de la cual se contempla sólo un cierto intervalo.

El canal lógico utilizado en cada trama de la multitrama se indica de la siguiente forma:

- F: FCCH
- S: SCH
- B: BCCH
- C: CCCH (PCH y AGCH)
- R: RACH
- Di: SDCCH, parte de datos
- Ai: SDCCH, parte de control