**GSM Radio Air Interface, GSM Slot & Burst**

*The GSM air interface / radio interface along wit the burst and slot schemes enable GSM to operate in a highly effective manner.*

**GSM primer includes:**  
[GSM introduction](https://www.electronics-notes.com/articles/connectivity/2g-gsm/basics-introduction.php)     [Network architecture](https://www.electronics-notes.com/articles/connectivity/2g-gsm/network-architecture.php)     [Network interfaces](https://www.electronics-notes.com/articles/connectivity/2g-gsm/network-interfaces.php)     [RF interface / slot & burst](https://www.electronics-notes.com/articles/connectivity/2g-gsm/rf-air-interface-slot-burst.php)     [GSM frames](https://www.electronics-notes.com/articles/connectivity/2g-gsm/frame-structure-superframe-hyperframe-multiframe.php)     [Power classes & control](https://www.electronics-notes.com/articles/connectivity/2g-gsm/power-amplifier-control-classes.php)     [Channels](https://www.electronics-notes.com/articles/connectivity/2g-gsm/logical-physical-channels.php)     [Audio codecs / vocoders](https://www.electronics-notes.com/articles/connectivity/2g-gsm/audio-codecs-vocoders-amr-celp.php)     [Handover](https://www.electronics-notes.com/articles/connectivity/2g-gsm/handover-handoff.php)

The GSM air interface of radio interface was given a considerable amount of thought and includes some features that mean that it operates very well and reduces the cost of the mobiles.

The form of modulation used is easy to generate and enables the handset power amplifiers to operate efficiently whilst also enabling sufficient data to be transferred. This enabled battery life to extend to many days on some handsets.

The slot scheme also enables the transmitter and receiver to operate at different times, removing the need for a costly duplexer scheme within the handsets.

These and other features meant that the GSM radio interface or air interface provided a level of performance that was not matched by many other systems of the time. Even today, the modulation formats used are not as battery efficient.



**GSM signal and GMSK modulation characteristics**

The core of any radio based system is the format of the radio signal itself. The carrier is modulated using a form of phase sift keying known as Gaussian Minimum Shift Keying (GMSK). GMSK was used for the GSM system for a variety of reasons:

* It is resilient to noise when compared to many other forms of modulation.
* Radiation outside the accepted bandwidth is lower than other forms of phase shift keying.
* It has a constant power level which allows higher efficiency RF power amplifiers to be used in the handset, thereby reducing current consumption and conserving battery life.

The nominal bandwidth for the GSM signal using GMSK is 200 kHz, i.e. the channel bandwidth and spacing is 200 kHz. As GMSK modulation has been used, the unwanted or spurious emissions outside the nominal bandwidth are sufficiently low to enable adjacent channels to be used from the same base station. Typically each base station will be allocated a number of carriers to enable it to achieve the required capacity.

The data transported by the carrier serves up to eight different users under the basic system by splitting the carrier into eight time slots. The basic carrier is able to support a data throughput of approximately 270 kbps, but as some of this supports the management overhead, the data rate allotted to each time slot is only 24.8 kbps. In addition to this error correction is required to overcome the problems of interference, fading and general data errors that may occur. This means that the available data rate for transporting the digitally encoded speech is 13 kbps for the basic vocoders.

**GSM slot structure and multiple access scheme**

GSM uses a combination of both TDMA and FDMA techniques. The FDMA element involves the division by frequency of the (maximum) 25 MHz bandwidth into 124 carrier frequencies spaced 200 kHz apart as already described.

The carriers are then divided in time, using a TDMA scheme. This enables the different users of the single radio frequency channel to be allocated different times slots. They are then able to use the same RF channel without mutual interference. The slot is then the time that is allocated to the particular user, and the GSM burst is the transmission that is made in this time.

Each GSM slot, and hence each GSM burst lasts for 0.577 mS (15/26 mS). Eight of these burst periods are grouped into what is known as a TDMA frame. This lasts for approximately 4.615 ms (i.e.120/26 ms) and it forms the basic unit for the definition of logical channels. One physical channel is one burst period allocated in each TDMA frame.

There are different types of frame that are transmitted to carry different data, and also the frames are organised into what are termed multiframes and superframes to provide overall synchronisation.

**GSM slot structure**

These GSM slot is the smallest individual time period that is available to each mobile. It has a defined format because a variety of different types of data are required to be transmitted.

Although there are shortened transmission bursts, the slots is normally used for transmitting 148 bits of information. This data can be used for carrying voice data, control and synchronisation data.

GSM slots  
*Note: offset between transmit and receive*

It can be seen from the GSM slot structure that the timing of the slots in the uplink and the downlink are not simultaneous, and there is a time offset between the transmit and receive. This offset in the GSM slot timing is deliberate and it means that a mobile that which is allocated the same slot in both directions does not transmit and receive at the same time. This considerably reduces the need for expensive filters to isolate the transmitter from the receiver. It also provides a space saving.

**GSM burst**

The GSM burst, or transmission can fulfil a variety of functions. Some GSM bursts are used for carrying data while others are used for control information. As a result of this a number of different types of GSM burst are defined.

* Normal burst   *uplink and downlink*
* Synchronisation burst  *downlink*
* Frequency correction burst  *downlink*
* Random Access (Shortened Burst)   *uplink*

**GSM normal burst**

This GSM burst is used for the standard communications between the basestation and the mobile, and typically transfers the digitised voice data.

The structure of the normal GSM burst is exactly defined and follows a common format. It contains data that provides a number of different functions:

1. ***3 tail bits:***   These tail bits at the start of the GSM burst give time for the transmitter to ramp up its power
2. ***57 data bits:***   This block of data is used to carry information, and most often contains the digitised voice data although on occasions it may be replaced with signalling information in the form of the Fast Associated Control CHannel (FACCH). The type of data is indicated by the flag that follows the data field
3. ***1 bit flag:***   This bit within the GSM burst indicates the type of data in the previous field.
4. ***26 bits training sequence:***   This training sequence is used as a timing reference and for equalisation. There is a total of eight different bit sequences that may be used, each 26 bits long. The same sequence is used in each GSM slot, but nearby base stations using the same radio frequency channels will use different ones, and this enables the mobile to differentiate between the various cells using the same frequency.
5. ***1 bit flag***  Again this flag indicates the type of data in the data field.
6. ***57 data bits***   Again, this block of data within the GSM burst is used for carrying data.
7. ***3 tail bits***   These final bits within the GSM burst are used to enable the transmitter power to ramp down. They are often called final tail bits, or just tail bits.
8. ***8.25 bits guard time***   At the end of the GSM burst there is a guard period. This is introduced to prevent transmitted bursts from different mobiles overlapping. As a result of their differing distances from the base station.

GSM Normal Burst

**GSM synchronisation burst**

The purpose of this form of GSM burst is to provide synchronisation for the mobiles on the network.

1. ***3 tail bits:***   Again, these tail bits at the start of the GSM burst give time for the transmitter to ramp up its power
2. ***39 bits of information:***
3. ***64 bits of a Long Training Sequence:***
4. ***39 bits Information:***
5. ***3 tail bits***   Again these are to enable the transmitter power to ramp down.
6. ***8.25 bits guard time:***   to act as a guard interval.

GSM Synchronisation Burst

**GSM frequency correction burst**

With the information in the burst all set to zeros, the burst essentially consists of a constant frequency carrier with no phase alteration.

1. ***3 tail bits:***   Again, these tail bits at the start of the GSM burst give time for the transmitter to ramp up its power.
2. ***142 bits all set to zero:***
3. ***3 tail bits***   Again these are to enable the transmitter power to ramp down.
4. ***8.25 bits guard time:***   to act as a guard interval.

GSM Frequency Correction Burst

**GSM random access burst**

This form of GSM burst used when accessing the network and it is shortened in terms of the data carried, having a much longer guard period. This GSM burst structure is used to ensure that it fits in the time slot regardless of any severe timing problems that may exist. Once the mobile has accessed the network and timing has been aligned, then there is no requirement for the long guard period.

1. ***7 tail bits:***   The increased number of tail bits is included to provide additional margin when accessing the network.
2. ***41 training bits:***
3. ***36 data bits:***
4. ***3 tail bits***   Again these are to enable the transmitter power to ramp down.
5. ***69.25 bits guard time:***   The additional guard time, filling the remaining time of the GSM burst provides for large timing differences.

GSM Random Access Burst

**GSM discontinuous transmission (DTx)**

A further power saving and interference reducing facility is the discontinuous transmission (DTx) capability that is incorporated within the specification. It is particularly useful because there are long pauses in speech, for example when the person using the mobile is listening, and during these periods there is no need to transmit a signal. In fact it is found that a person speaks for less than 40% of the time during normal telephone conversations. The most important element of DTx is the Voice Activity Detector. It must correctly distinguish between voice and noise inputs, a task that is not trivial. If a voice signal is misinterpreted as noise, the transmitter is turned off an effect known as clipping results and this is particularly annoying to the person listening to the speech. However if noise is misinterpreted as a voice signal too often, the efficiency of DTX is dramatically decreased.

It is also necessary for the system to add background or comfort noise when the transmitter is turned off because complete silence can be very disconcerting for the listener. Accordingly this is added as appropriate. The noise is controlled by the SID (silence indication descriptor).