Intent Research Scientific Journal-(IRSJ)
ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index

FEATURES OF SIGNAL FORMATION IN THE GSM STANDARD

Korotkova Larisa Aleksandrovna
Senior Teacher

Khudoyberganov Shavkat Karimovich
Senior Lecturer

Zhabborov Alibek Botirkul
Senior Teacher

Rakhimov Zhamshid Norboy
Assistant
Tashkent State Technical University,
Department of Radio Engineering Devices and Systems +998 946905731.

Abstract:
This article is devoted to the principles of the formation of channels in the system, their structure and properties.

Keywords: frequency plan, principles of signal generation, channel modulation, GMSK signal generation, frame structure.

Frequency plan in the GSM standard.

Two frequency bands are allocated for GSM 900 radio access:

890–915 MHz for the communication channel from the subscriber to the station (MS to BS direction);

935–960 MHz for outgoing channel from station to subscriber (BS to MS directions).

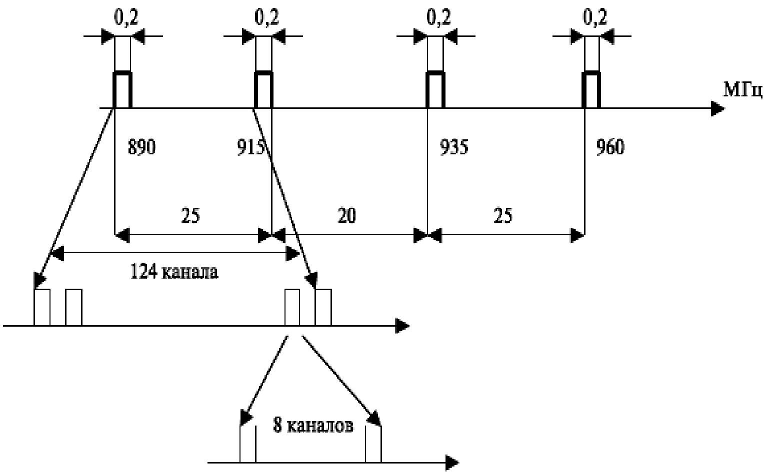
The 25 MHz bands are divided into 124 pairs of channels operating in full duplex mode with a carrier frequency interval of 200 kHz, using Frequency Division Multiple Access (FDMA).).[1]

Each radio channel with a bandwidth of 200 kHz is divided into temporary cells, which create 8 logical channels. Time Division Multiple Access (TDMA) contains 8 slots and 248 physical half-duplex channels, making up a group of

1984 half-duplex channels. With a cluster size of 7 (frequency reuse), the number of channels in one cell is approximately 283 (1984 / 7) half-duplex channels (see Figure 1)

When transmitting over one voice channel, the GSM standard uses a normal time interval NB (packet) of 0.577 ms duration, which includes:

- 114 bits encrypted message;
- two terminal combinations TV (Tail Bits) of 3 bits each;
- two control bits separating the encrypted bits of the message and the reference sequence;
- GP guard interval (Guard Period) with a duration equal to the transmission time of 8.25 bits.



Picture 1. - Formation of channels in the GSM system

Signal generation in the GSM standard.

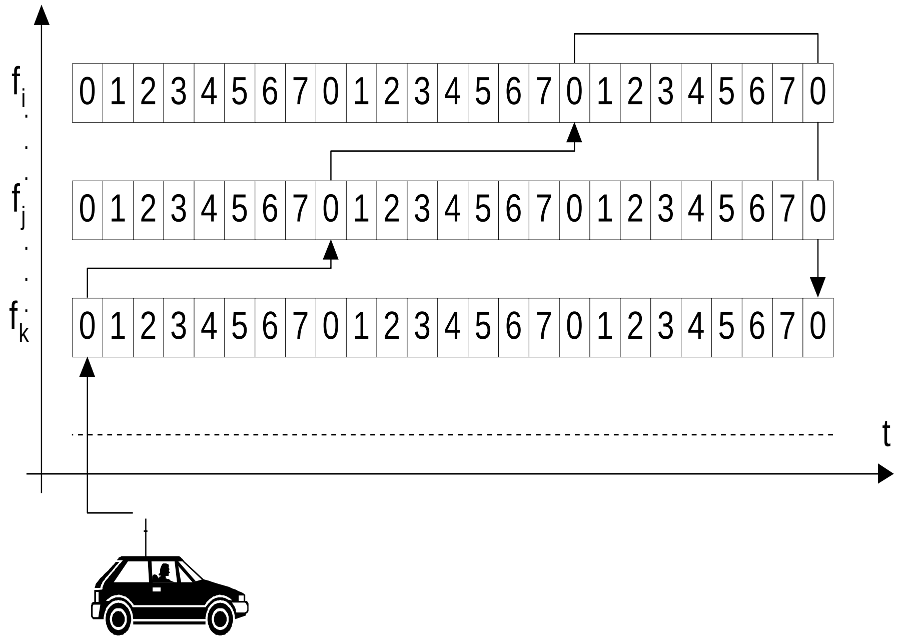
Using slow frequency hops during a communication session – SFH (Slow Frequency Hopping).

The main purpose of such hops is to provide frequency diversity in radio channels operating in conditions of multipath propagation of radio waves. Slow frequency hopping is used in all mobile networks, which improves the efficiency of coding and interleaving when subscriber stations are moving slowly.)[1]

The principle of forming slow frequency hops is that a message transmitted in the time interval of a TDMA frame of 0.577 ms allocated to the subscriber is transmitted (received) at a new fixed frequency in each subsequent frame, Figure

2. In accordance with the frame structure, the time for restructuring frequency is about 1 ms.

During frequency hopping, a 45 MHz separation between the receive and transmit channels is constantly maintained. All active subscribers located in the same cell are assigned non-overlapping frequency switching sequences, which eliminates mutual interference when subscribers receive messages (Picture 2)



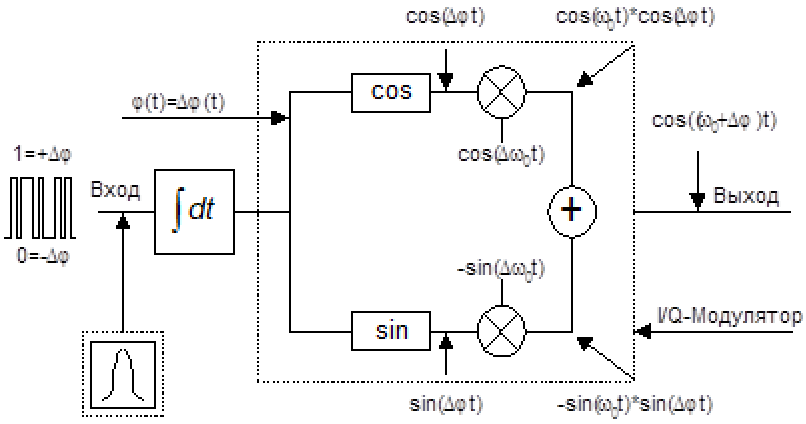
Picture 2 - Principles of formation of slow frequency jumps.

Gaussian Frequency Shift Keying (GMSK)

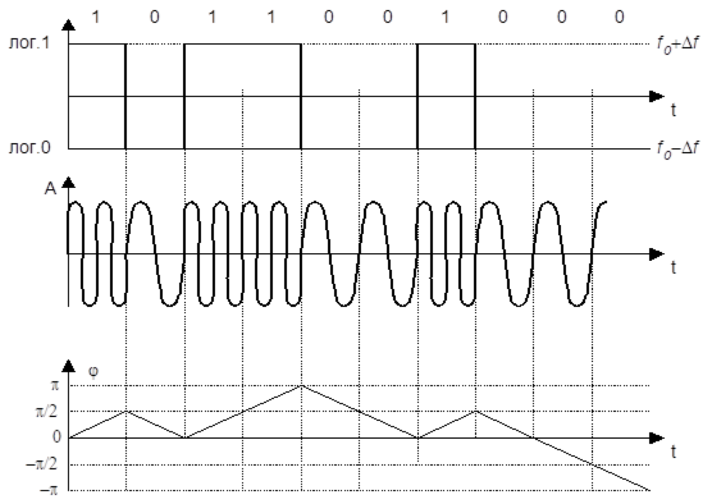
In the GSM standard, Gaussian frequency shift keying with minimal frequency shift - GMSK - is selected.

Gaussian minimum keying (GMSK) differs in that the input sequence pulses are smoothed using a low-pass filter and reduced to a Gaussian curve shape. This shape provides lower levels of out-of-band emissions and reduces interference to adjacent channels.

ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index



Picture 3- Principle of GMSK signal formation



Picture 4 - GMSK signal generation

Properties of GMSK modulation.

- constant level envelope, allowing the use of transmitting devices with power class C amplifiers;

-narrow spectrum at the output of the power amplifier of the transmitting device ensuring a low level of out-of-band radiation;

- good noise immunity of the communication channel.).[2]

Frame structure in the GSM standard

A traffic multiframe contains 26 temporary access (TDMA) frames, each of which consists of 8 packets (burst1)) of traffic. The duration of a traffic multiframe is 120 ms. Therefore, the duration of temporary access frames is 120 ms / 26 = 4.615 ms, and the duration of the temporary position (slot) of traffic is 120/26 x 8 = 15/26 = 0.577 µs. Of the 26 frames, 24 are used for traffic, one

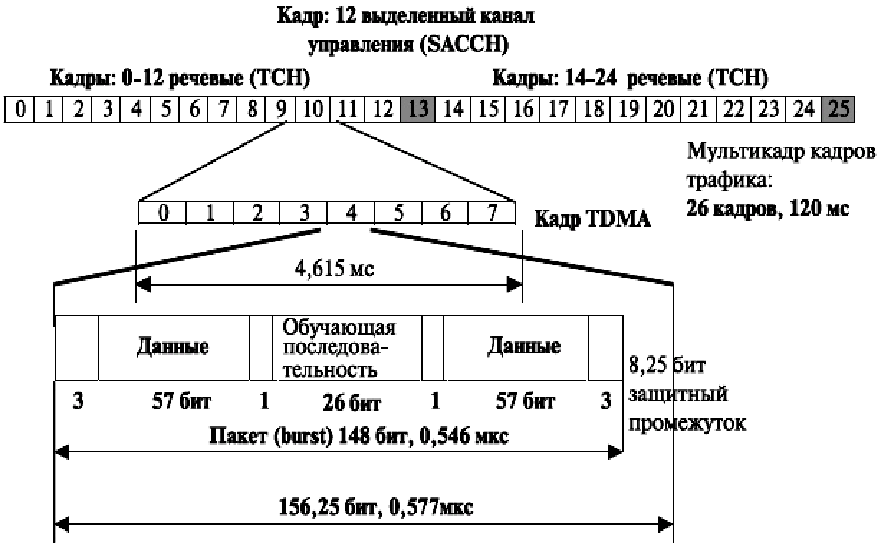
Intent Research Scientific Journal-(IRSJ)
ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index

(12th frame) is used as a low-speed dedicated control channel (SACCH - Slow Associated Control Channel) and one (25th) is currently not used (Picture 5).

Package contains:

- two data fields of 57 bits each, i.e. one packet contains 114 bits of information;

-field of the training sequence. This sequence is used to evaluate the characteristics of the radio channel. It is a set of predetermined signs, the distortion of which determines the quality of the radio channel;



Picture 5 - Frame structure in a channel

- “tail bits”, located at the edges of one block and indicating its boundaries. They protect information when a slot is shifted;

-one-bit fields - are flags that indicate the type of information. The packet can be used to carry both traffic and control frames.).[1]

Structure of GSM radio access traffic frames

The traffic framing structure (TCH) of the forward and reverse directions is divided in time into 3 packet transmission periods. Therefore, the mobile station cannot receive and receive the same channel at the same time, which simplifies its electronic design.

Data is transmitted in packets that are placed in slots. The total number of bits in a traffic multiframe is 156.25 bits x 8 x 26 = 32500 bits. These bits are transmitted in 120 ms. Therefore, the bit rate of information is 270.833 Kbps (32500/0.12=270.833 Kbps). The transmission time of one bit is 3.69 µs. To counteract the effects of timing errors, time dispersion, etc., the data packet is

ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index

slightly shorter than the time interval. For one packet it is 148 bits out of 156.25 bits transmitted within the slot. In addition to THC's full speed channels, THC's half speed channels can be used. Half-speed THC's can actually double system capacity because they offer speech encoding at 11.4 Kbps instead of 22.8 Kbps. Half-speed THC's channels are also used to transmit control signals.
If half-rate coding is used, then the number of slots increases to 16. In this case, even frames of the multiframe contain information from slots 0–7, and odd frames contain information from slots 8–15.) [1]

Control slot structures

The frequency correction slot (FB - Frequency correction Burst) is designed to synchronize the frequencies of the mobile station. To transmit these slots, a frequency adjustment channel (FCCH - Frequency Correction Channel) is allocated.
The synchronization slot (SCH - Synchronization Burst) is designed for time synchronization of the base and mobile stations. The slot contains a synchronization sequence (64 bits), encrypted information about the TDMA frame number and the base station identification code, two blocks (39 bits each). To transmit these slots, a separate synchronization channel (SCH - Synchronizing Channel) is allocated.
Empty slot (DB - Dummy Burst) - this auxiliary packet contains two 58-bit fields that do not carry information. Such a packet is transmitted to notify that the station is in working condition.
The access slot (AB - Access Burst) is designed to allow MS access to the BSS, transmitted over the access rights channel (RACH - Random Access Channel). This slot is transmitted as the first request when the stations have not yet entered synchronous mode and the signal transit time is unknown. It contains the trailer (TB) - in this case it consists of 8 bits; The synchronization sequence for the base station is 41 bits, which allows the base station to begin the synchronization process and ensure that the subsequent 36 bits are correctly received. The large guard interval (68.25 bits with a duration of 252 μs) provides maximum time to protect frames from the effects of intersymbol distortion. All slots have the same length of 156.25 bits and duration of 235.833 μs. All slots, except the access slot, have tail bits (TB - Tail Bit) of 3 bits each, and a guard interval of 8.25 bits.

Intent Research Scientific Journal-(IRSJ)
ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index

Organization of physical channels

Traffic channels are used to transmit the fast associated control channel (FACCH - Fast Associated Control Channel) and the low-speed dedicated control channel (SACCH - Slow Associated Control Channel). A traffic packet can be used to carry both traffic and control frames.

Of the 26 frames, 24 are used for traffic, one (12th frame) is used as a low-speed dedicated control channel (SACCH - Slow Associated Control Channel). One (25th) is currently not used, but in half-speed mode it can be used to organize a second SACCH channel. For transmission in the 12th frame, 8 slots can work.

Since one SACCH channel in full-speed mode occupies one slot with an information field of 114 bits, and the transmission time is 0.12 s, the transmission speed on this channel is 114/0.12 = 950 bps.

FACCH channel slots are transmitted at the traffic slot rate. The remaining control channels are transmitted in a control multiframe containing 51 frames.) [2]

Speech coding

For GSM, long-term linear prediction with regular pulse sequence excitation (RPE - LPC) is selected. This method is based on the principle of prediction, where information from previous time samples is used to predict the current time sample. The coefficients of the linear combination of the previous timing samples, plus the encoded form of the residuals, the difference between the predicted and actual timing samples, represent the signal. Speech is divided into 20 time samples per millisecond, each of which is encoded as 260 bits, giving a total data rate of 13 Kbps. This is the so-called Full Rate speech coding [3]

Methods for improving the quality of signal transmission

1) Suppression of distortions due to multipath propagation.

In the 900 MHz band, radio waves bounce off everything - buildings, hills, cars, airplanes, etc. Thus, many reflected signals, each with a different phase, can reach the receiving antenna and cause fading. Fading is a phenomenon in which a signal gradually increases or decreases over a certain period of time. Distortion reduction is used to extract the desired signal from unwanted reflections. It works by detecting how a known transmitted signal is corrupted by multipath

Intent Research Scientific Journal
IRSJ

fading and adjusts an inverse filter to extract the rest of the transmitted signal. This known signal is the 26 bits of the training sequence transmitted in the middle of each packet time slot. The practical implementation of the compensator is not defined in the GSM specifications.

2) Frequency jump.

The mobile station allows the use of any of the specified frequencies: this means that the frequency can be changed between the transmitter and the receiver and controlled within a single TDMA frame. GSM uses this property to implement slow frequency hopping when the mobile station and BTS each transmit on a different carrier frequency. The frequency hopping algorithm is broadcast and controls via the Broadcast Control Channel (BCCH). Since multipath fading depends on the carrier frequency, slow frequency hops help alleviate the interference problem. In addition, inter-channel interference is actually random and not mutually related.

3) Intermittent transmission.

Reducing cross-channel interference is a goal of any cellular system, as it allows for better service for a given cell size or the use of smaller cells, which increases the overall capacity of the system. Discontinuous transmission (DTX - Discontinuous transmission mode) is a method whose advantage is based on the fact that a person actually speaks less than 40 percent of the time during a normal communication session. It is therefore possible to turn off the transmitter during periods of silence. An additional benefit is that DTX saves mobile station energy.

The most important component of the DTX is the Voice Activity Detection (VAD) device. It must distinguish speech from noise. If the speech signal is incorrectly interpreted as noise, the transmitter is turned off and a very annoying effect called clipping occurs at the receiving end. If, on the other hand, noise is misinterpreted too often as a speech signal, the effectiveness of DTX is dramatically reduced.

Intent Research Scientific Journal-(IRSJ)
ISSN (E): 2980-4612
Volume 2, Issue 9, September-2023
Website: intentresearch.org/index.php/irsj/index

4) Intermittent reception.

Another method of conserving energy in a mobile station is intermittent reception. The short message broadcast channel (Paging Channel), used by the base station to signal a call from the base station to the mobile station, is structured into subchannels. Each mobile station shall receive only its own sub-channel. In call idle mode, during the period of time between successive sub-channels, the mobile station can be placed in a mode where almost no power is consumed. [4]

References

1 Konshin S.V., Sabdykeeva G.G. Theoretical foundations of communication systems with moving objects: Textbook. – Almaty: AIES, 2007.
2 Klochkovskaya L.P., Konshin S.V. Wireless technology. Calculation of mobile communication parameters. Tutorial. – Almaty: AIES, 2007.
3 Odinsky A. Promising mobile radio communication technologies Informost, No. 2(20), 2008, http://www.radioscanner.ru.
4 Rusev D. Wireless access technologies: Directory. – St. Petersburg: BHV-Petersburg, 2007.