MOTOROLA

Chapter 5

Channels on the Air Interface

Channels on the Air Interface

Section Objectives

On completion of this section the student will be able to:

- Understand why GMSK is used to modulate the GSM signal.
- Name the four most commonly used channel combinations and provide reasons why each would be used.
- State the reason why multiframes, superframes and hyperframes are utilized.

Transmission of Analogue and Digital Signals

The main reasons why GSM uses a digital air interface:

- It is "noise robust", enabling the use of tighter frequency re-use patterns and minimizing interference problems;
- It incorporates error correction, thus protecting the traffic that it carries;
- It offers greatly enhanced privacy to subscribers and security to network providers;
- It is ISDN compatible, uses open standardized interfaces and offers an enhanced range of services to its subscribers.

Modulation Techniques

There are three methods of modulating a signal so that it may be transmitted over the air:

- **Amplitude Modulation (AM)**

  Amplitude Modulation is very simple to implement for analogue signals but it is prone to noise.

- **Frequency Modulation (FM)**

  Frequency Modulation is more complicated to implement but provides a better tolerance to noise.

- **Phase Modulation (PM)**

  Phase Modulation provides the best tolerance to noise but it is very complex to implement for analogue signals and therefore is rarely used.

Digital signals can use any of the modulation methods, but phase modulation provides the best noise tolerance. Since phase modulation can be implemented easily for digital signals, this is the method which is used for the GSM air interface. Phase Modulation is known as Phase Shift Keying (PSK) when applied to digital signals.

Modulation Techniques

1. **Amplitude Modulation (AM)**
2. **Frequency Modulation (FM)**
3. **Phase Shift Keying (PSK)**

Transmission of Digital Signals

Phase Shift Keying (PSK)

Phase modulation provides a high degree of noise tolerance. However, there is a problem with this form of modulation. When the signal changes phase abruptly, high frequency components are produced, thus a wide bandwidth would be required for transmission.

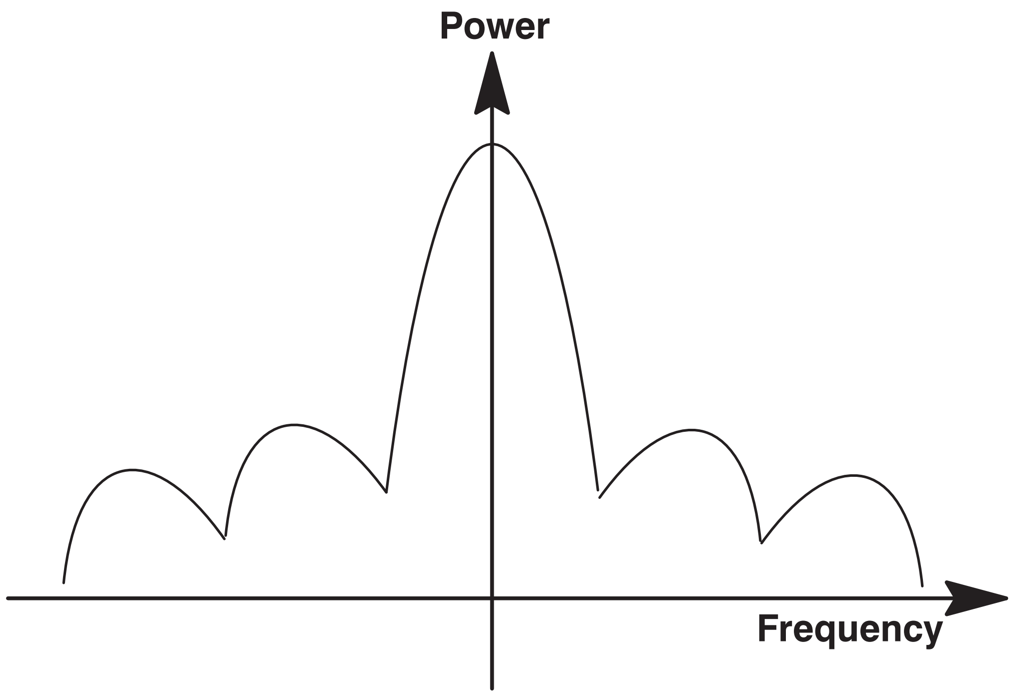
GSM has to be as efficient as possible with the available bandwidth. Therefore, it is not this technique, but a more efficient development of phase modulation that is actually used by the GSM air interface, it is called Gaussian Minimum Shift Keying (GMSK).

Gaussian Minimum Shift Keying (GMSK)

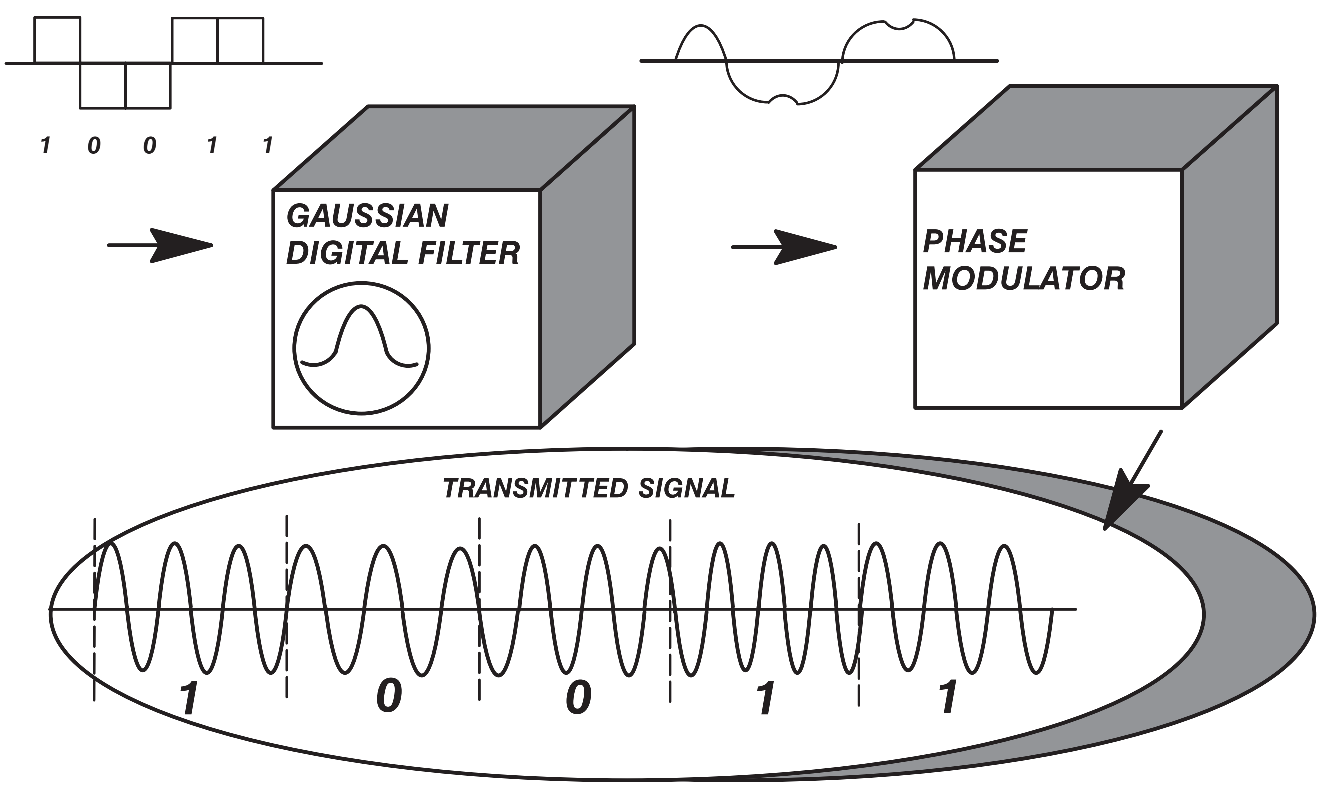
With GMSK, the phase change which represents the change from a digital ‘1’ or a ‘0’ does not occur instantaneously as it does with Binary Phase Shift Keying (BPSK). Instead it occurs over a period of time and therefore the addition of high frequency components to the spectrum is reduced.

With GMSK, first the digital signal is filtered through a Gaussian filter. This filter causes distortion to the signal, the corners are rounded off. This distorted signal is then used to phase shift the carrier signal. The phase change therefore is no longer instantaneous but spread out.

Frequency Spectrum



Gaussian Minimum Shift Keying (GMSK)



Physical and Logical Channels

The physical channel is the medium over which the information is carried, in the case of a terrestrial interface this would be a cable. The logical channels consist of the information carried over the physical channel.

GSM Physical Channels

A single GSM RF carrier can support up to eight MS subscribers simultaneously. The diagram opposite shows how this is accomplished. Each channel occupies the carrier for one eighth of the time. This is a technique called *Time Division Multiple Access.*

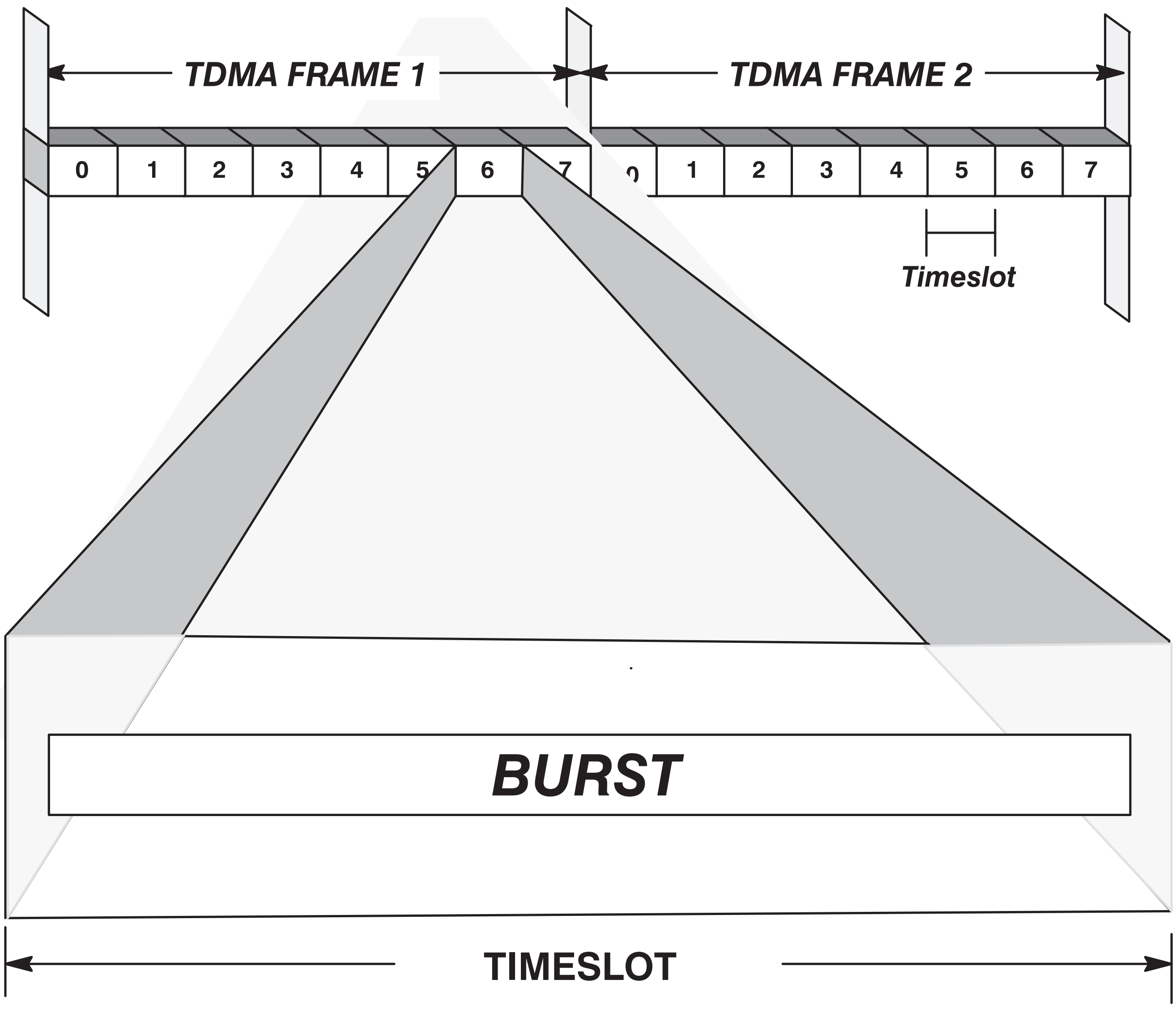
Time is divided into discrete periods called *"timeslots".* The timeslots are arranged in sequence and are conventionally numbered 0 to 7. Each repetition of this sequence is called a "TDMA frame".

Each MS telephone call occupies one timeslot (0–7) within the frame until the call is terminated, or a handover occurs. The TDMA frames are then built into further frame structures according to the type of channel. We shall later examine how the information carried by the air interface builds into frames and multi-frames and discuss the associated timing.

For such a system to work correctly, the timing of the transmissions to and from the mobiles is critical. The MS or Base Station must transmit the information related to one call at exactly the right moment, or the timeslot will be missed. The information carried in one timeslot is called a *"burst"*.

Each data burst, occupying its allocated timeslot within successive TDMA frames, provides a single GSM physical channel carrying a varying number of logical channels between the MS and BTS.

Timeslots and TDMA Frames



GSM Logical Channels

There are two main groups of logical channels, traffic channels and control channels.

Traffic Channels (TCH)

The traffic channel carries speech or data information. The different types of traffic channel are listed below:

Full rate

- TCH/FS: Speech (13 kbit/s net, 22.8 kbit/s gross)
- TCH/EFR: Speech (12.2 kbit/s net, 22.8 kbit/s gross)
  TCH/F9.6: 9.6 kbit/s – data
  TCH/F4.8: 4.8 kbit/s – data
  TCH/F2.4 2.4 kbit/s – data

Half rate

- TCH/HS: speech (6.5 kbit/s net, 11.4 kbit/s gross)
  TCH/H4.8 4.8 kbit/s – data
  TCH/H2.4 2.4 kbit/s – data

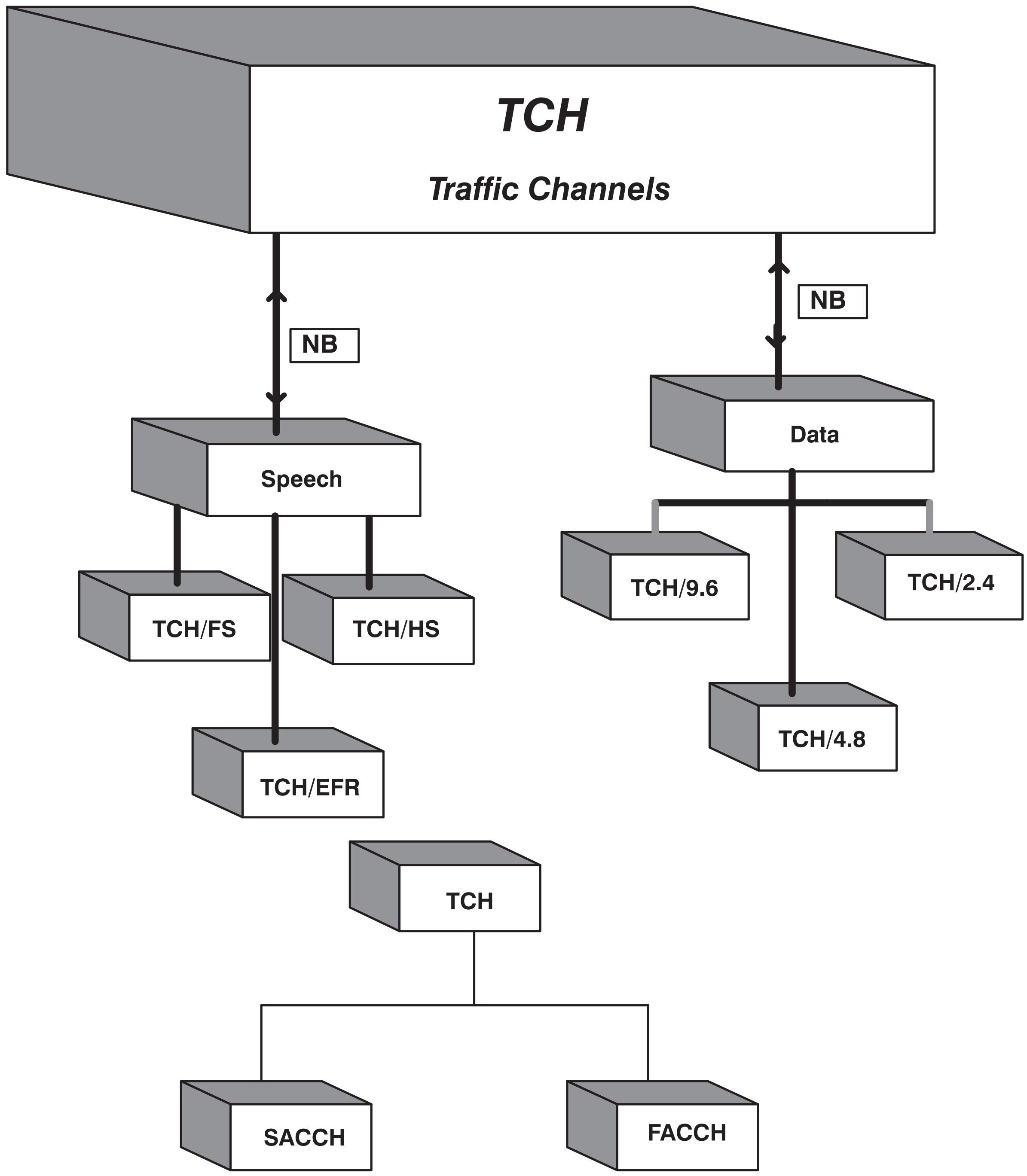
Acronyms:

TCH	Traffic Channel
TCH/FS	Full rate speech channel
TCH/EFR	Enhanced full rate speech
TCH/HS	Half rate speech channel
TCH/9.6	Data channel 9.6 kbit/s
TCH/4.8	Data channel 4.8 kbit/s
TCH/2.4	Data channel 2.4 kbit/s

Speech Channels

Speech channels are supported by two different methods of coding known as Full Rate (FR) and Enhanced Full Rate (EFR). Enhanced Full Rate coding provides a speech service that has improved voice quality from the original Full Rate speech coding, whilst using the same air interface bandwidth. EFR employs a new speech coding algorithm and additions to the full rate channel coding algorithm to accomplish this improved speech service, however, it will only be supported by Phase 2+ mobiles onwards.

Channels on the Air Interface



ACRONYMS

NB	=	***Normal Burst***
SACCH	=	***Slow Associated Control Channel***
FACCH	=	***Fast Associated Control Channel***

GSM Control Channel Groups

These are: Broadcast Control Channel (BCCH); Common Control Channel (CCCH); Dedicated Control Channel (DCCH).

BCCH Group

The Broadcast Control Channels are downlink only (BSS to MS) and comprise the following:

- BCCH carries information about the network, a MSs present cell and the surrounding cells. It is transmitted continuously as its signal strength is measured by all MSs on surrounding cells.
- The Synchronizing Channel (SCH) carries information for frame synchronization.
- The Frequency Control Channel (FCCH) provides information for carrier synchronization.

CCCH Group

The Common Control Channel Group works in both uplink and downlink directions.

- Random Access Channel (RACH) is used by MSs to gain access to the system.
- Paging Channel (PCH) and Access Granted Channel (AGCH) operate in the “downlink” direction. The AGCH is used to assign resources to the MS, such as a Stand-alone Dedicated Control Channel (SDCCH). The PCH is used by the system to call a MS. The PCH and AGCH are never used at the same time.
- Cell Broadcast Channel (CBCH) is used to transmit messages to be broadcast to all MSs within a cell, for example, road traffic information, sporting results.

DCCH Group

Dedicated Control Channels are assigned to a single MS for call setup and subscriber validation. DCCH comprises:

- Stand-alone Dedicated Control Channel (SDCCH) which supports the transfer of Data to and from the MS during call setup and validation.
- Associated Control Channel. This consists of Slow ACCH which is used for radio link measurement and power control messages. Fast ACCH is used to pass “event” type messages, for example, handover messages. Both FACCH and SACCH operate in uplink and downlink directions.

Acronyms

BCCH	Broadcast Control Channel	CCCH	Common Control Channel
DCCH	Dedicated Control Channel	ACCH	Associated Control Channel
SDCCH	Stand-alone Dedicated Control Channel	RACH	Random Access Channel
		PCH	Paging Channel
AGCH	Access Grant Channel	CBCH	Cell Broadcast Channel

Control Channels