



Modulation Signal Description

GSM

Another approach to cellular radio is the European standard GSM (Global System for Mobile). This system implemented digital methods right from the start in an attempt to accommodate an increasing number of users and establish compatibility with other systems. In addition, GSM provides a wide array of cell areas (from microcells at 200 m. to macrocells at 35 km) with the possibility of servicing "in-car communications" at up to 250 km/hr. The proposed design would provide the user with data communications via fax, e-mail, and file transfer, in addition to voice. This wide application requirement results in a higher performance demand. Hence, the details of the signaling scheme under the European standard are more complicated than other schemes [4]. In essence, the system uses TDMA and frequency multiplexes the signals. The signals are transmitted using a Gaussian Minimum Shift Keying (GMSK) scheme.

GMSK is a form of binary signaling schemes which represent digital states as a shift between discrete sinusoidal frequencies called Frequency Shift Keying (FSK). Minimum Shift Keying (MSK) is continuous phase FSK with the smallest possible modulation index h . Modulation index is defined as:

$$h = 2FTb$$

where F = Peak frequency deviation in Hz and Tb = Bit period in seconds

Two discrete frequencies, representing two distinct digital states, with equal phases at switch time $t = 0$ requires a minimum value of $h = 0.5$. The Gaussian part of GMSK describes the fact that the digital pulses are filtered in the time domain. This results in bits which are sinusoidal rather than square. The effective spectrum is then compressed with the average carrier frequency in the center of the passband. This is a great advantage because of the significantly reduced bandwidth. GMSK is utilized because of these bandwidth conservation properties.

The bandwidth for GSM is a 25 MHz up-link at 890-915 MHz and down-link at 935-960 MHz. The 25 MHz is divided into 125 channels, each of which is 200 kHz wide. Slight spectral spillage is allowed into neighboring channels (which is minimized by GMSK). This separated transmit/receive frequencies scheme under GSM enables easier duplex filtering.

Within the bandwidth, individual channels are subdivided into multiframes (made of 26 frames), frames (made of 8 time slots), and time slots (made of 8 fields). The time slots are 0.57 ms long allowing 156.25 bits of information including overhead. Each user is

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active during two time slots; one for transmit and one for receive. The other six time slots in the frame are used by the mobile for signal strength measurements [5]. The problem facing this scheme is that it suffers from multipath. Doppler effects with a high speed mobile user. A mobile user could conceivably traverse an entire wavelength in a time slot. Solutions to this problem involve switching the channel frequency of a given user. This is a form of Frequency Hopping (FH) (a version of spread spectrum that will be analyzed in detail later) is quite adept at resolving the problem of multipath. Basically, frequency hopping takes advantage of the fact that interference may be reduced if the interfering signal is contained in only a narrow portion of the spectrum over which the desired signal is hopping.

The present version of GSM supports 22.8 kbps full rate and 11.4 kbps half rate operation. In addition, this system naturally extends to use of data communications. GSM allows interfacing to audio modems and Integrated Services Digital Networks (ISDN) which support up to 9.6 kb/s.

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