EXHIBIT 9

DETAILED DESCRIPTION OF MODULATION SYSTEM

A detailed description of the modulation system employed is provided in this exhibit, per the requirements of § 2.1033(c)(13).

In general, the GSM system utilizes a Time Division Multiple Access (TDMA) scheme with eight basic physical channels per carrier. Carrier separation is 200 kHz. The basic radio resource is a time slot which lasts approximately 576.9 s during which information is transmitted at a modulation rate of approximately 270.833 kb/s. The modulation scheme is Gaussian MSK (GMSK) with a bandwidth-time (BT) product of 0.3.

The following description of the GSM modulation system is taken directly from Chapter 4 of Volume 1, Radio Path Physical Layer, in the Personal Communications Services, Air Interface Specification, J-STD-007.

4.0 Modulation

This chapter defines the theoretical requirements of the modulator, inclusive of the differential encoder. The modulator receives the bits from the encryption unit and produces and RF modulated signal. The information bits are first differentially encoded and then passed to the modulator. The modulation is GMSK (Gaussian Minimum Shift Keying) with a BT product of 0.3.

4.1 Modulation Format

4.1.1 Modulating Bit Rate

The modulating bit rate is 1/T = 1625/6 kb/s (approximately 270.833 kb/s).

4.1.2 Start and Stop of the Burst

The bits contained within a burst are defined in Chapter 2. For the purpose of the modulator specification at follows, the bits entering the differential encoder prior to the first bit of the burst and following the last bit of the burst are consecutive logical ones and are denoted by the term dummy bits which define the start and end points of the useful and active parts of the burst as shown in Figure 4.1. The actual state of these bits is left to the manufacturer's implementation subject to the requirement that all performance specifications of this volume are met. Nothing is specified about the actual phase of the modulator output signal outside of the useful part of the burst. Figure 4.1 depicts the relationship between the active and useful part of the burst, the tail bits and dummy bits for a normal burst. The useful part of the burst lasts for 147 modulating bits.

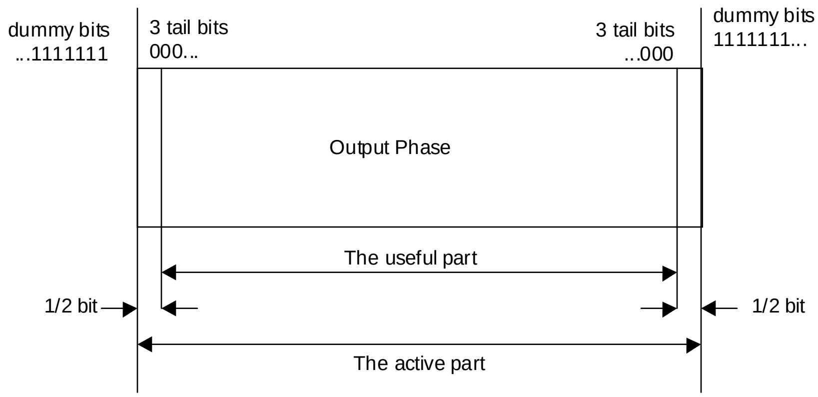

Figure 4.: Normal Burst

4.1.3 Differential Encoding

Each data value d_i = [0,1] is differentially encoded. The output of the differential encoder is:

$d'_i = d_i \oplus d_{i-1}$ where $\oplus$ denotes modulo 2 addition.

The modulating data value ${}_i$ input to the modulator is: ${}_i = 1 - 2d'_i$ where ${}_i$ {-1, 1}

4.1.4 Filtering

The modulating data values α_i as represented by Dirac pulses excite a linear filter with impulse response defined by:

$g(t) = h(t) \otimes rect(t/T)$

where the function rect(x) is defined by $rect(t/T) = 1/T$ for $|t| < T/2$

$rect(t/T) = 0$ otherwise

and $\otimes$ means convolution. h(t) is defined by

$$h(t) = \frac{e^{\left(\frac{-t^2}{2\sigma^2 T^2}\right)}}{\sqrt{2\pi}\sigma T}$$

where $\sigma = \sqrt{\ln(2)}/(2\pi BT)$ and BT = 0.3

where B is the 3 dB bandwidth of the filter with impulse response h(t) and T is the duration of the one input data bit.

4.1.5 Output Phase

The phase of the modulated signal is:

$$\vartheta(t') = \sum_i \alpha i \pi h \int_{-\infty}^{t'-iT} g(u)du$$

where the modulating index h is ½ (maximum phase change in radians is ½ per data interval).

The time reference t' = 0 is the start of the active part of the burst as shown in Figure 4. The is also the start of the bit period of bit number 0 (the first tail bit) as defined in chapter 2.

4.1.6 Modulation

The modulated RF carrier, except for start and stop of the TDMA burst may therefore be expressed as:

$$x(t') = \sqrt{\frac{2Ec}{T}} \cos(2\pi f_o t' + \varphi(t') + \vartheta_0$$

where Ec is the energy modulating bit, fo is the center frequency, and φo is a random phase and is constant during one burst.