To Synchronize and Detect SCH-burst for Time Synchronization in Wireless Telecommunication

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ABSTRACT

GSM uses TDMA/FDMA multiple-access scheme techniques for transmission and reception of data. Frequency correction burst(FCH-burst) and synchronization burst(SCH-burst), transmitted in broadcast control channel (BCCH) by the base station (BS), and are used in acquisition phase of frequency and timing synchronization respectively by the mobile station (MS). Synchronization Burst with an extended training sequence synchronizes the mobile station (MS) with the base station (BS) in time. In this paper, we have described a SCH-Burst generation and detection approach that synchronizes and detects the SCH burst which is the initial stage required for time synchronization in wireless Telecommunication for 2G system.

The detection of SCH-burst implementation approach for time synchronization in wireless telecommunication is done with transmitter and receiver block. AWGN and Multipath fading is introduced between transmitter and receiver to simulate the channel through which the GSM signal traverses. Transmitter section of BS generates bit sequence representing synchronization burst (SCH-burst) and performs a GMSK modulation to generate in-phase I and quadrature phase Q signal. I and Q signals are fed to AWGN/Fading channel to introduce AWGN noise and fading in the signal. The receiver section first detects and synchronizes in time to the SCH burst using correlation method. Once the SCH-Burst is detected then next stage involves demodulation and decoding to receive the synchronization burst which gives the timing information about the received burst in terms of frame number (FN) and base station identity code (BSIC) for Time Synchronization in wireless Telecommunication.

Categories and Subject Descriptors

C.2.1 Network Architecture and Design: Wireless communication

General Terms

Measurement, Performance, Design, Experimentation, Verification.

Keywords

SCH-burst, Modulation, synchronization, correlation, frame number, Time synchronization, GMSK Modulation, SCH-burst detection.

1. INTRODUCTION

In GSM system, when the mobile station (MS) starts, it has coarse frequency information but not precise and it doesn't have any timing and frequency information. To initiate and receive a call, and to get system information, an MS needs to camp on a suitable cell, and tune to it. Frequency correction (FCH) and synchronization (SCH) bursts, transmitted in BCCH (broadcast control channel) carrier, are used in acquisition phase of frequency and timing synchronization respectively. In Time synchronization, the first step involves synchronization and detection of SCH-burst and next step involves, obtaining the frame number and base station identity code (BSIC) of SCH-burst received at the receiver in BCCH carrier. In the described implementation approach we have assumed frequency synchronization is already achieved and need to synchronize and detect SCH-burst which is required to obtain timing synchronization that synchronizes the Mobile station with the BTS in time.

2. SCH-BURST TRANSCEIVER

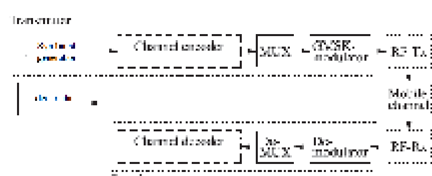

Figure 1. Block diagram of Sch-burst Transceiver.

2.1 Sch-burst Transmitter Structure

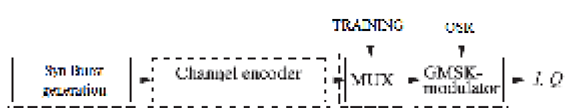

Figure 2. Overall structure of Sch-burst transmitter.

The overall structure of the implemented SCH-burst transmitter is illustrated in Fig. 2. The input and output labels TRAINING, OSR, I, and Q all relate to the actual parameters used in the implementation. The transmitter is, as illustrated, made up of four distinct functional blocks. To provide an input data stream to the channel encoder a sequence of synchronization burst data bits are generated by the Syn. burst generator. Channel encoding is performed using half rate convolution encoder. The encoded sequence is then accepted by the MUX which is basically a frame formatter which splits the incoming sequence to form a GSM synchronization burst. This burst type requires a TRAINING sequence which is included by the MUX as shown in Fig. 2. The term TRAINING is also used throughout the software implementations to represent the training sequence. Upon having generated the prescribed GSM synchronization burst data structure the MUX returns this to the GMSK modulator, where GMSK is short for Gaussian Minimum Shift Keying. The GMSK-modulator block performs a differential encoding of the incoming burst to form a NRZ (Non Return to Zero) sequence. This modified sequence is then subject to the actual GMSK-modulation after which, the resulting signal is represented as a complex baseband signal using the corresponding I and Q signals. The number of sample values per data bit is left as a user definable parameter. It is here customary to operate using four samples per bit hence; an OSR of four is normally used [8].

2.2 Sch-burst Receiver Structure

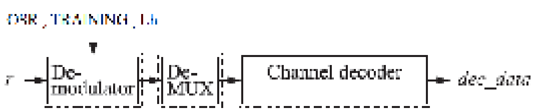

Figure 3. Overall structure of Sch-burst Receiver

The overall structure of the implemented data receiver is illustrated in Fig. 3. The input and output labels r, TRAINING, OSR, and dec_data all relate to the actual parameters used in the implementation. Here three Functional blocks are designed in order to implement the data receiver. The demodulator accepts a GSM burst, r, using a complex baseband representation. Based on this data sequence, information concerning the oversampling rate OSR, the training sequence TRAINING, and the desired length of the receiving filter, Lh, the demodulator determines the most probable bit sequence. This demodulated sequence is then used as input to the DeMUX where the bits are split in order to retrieve the actual data bits from the sequence. The remaining control bits and the training sequence are here discharged. It is important to note that the parameter values of OSR and TRAINING used in the receiver must equal those used in the transmitter.

3. DATA GENERATION

Figure 4. GSM Synchronization burst structure.

The function burst_gen generates a bit sequence representing GSM synchronization burst [10] which includes tail, encrypted data bits, and a training sequence. Since channel encoding is optional it is not considered further in the document. Multiplexer places the training sequence in appropriately in a frame structure. The implemented burst, referred to as a GSM synchronization burst, has the structure displayed in Fig. 4.

4. GMSK MODULATION

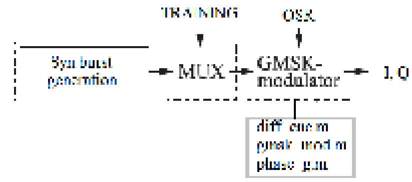

Figure 5. GMSK-Modulator

The implemented GMSK-modulator is made up of three functional blocks, namely differential encoder, gmsk-modulator and phase-genarator implemented using functions diff_enc.m, gmsk_mod.m, and phase_g.m, as illustrated in Fig. 5.

4.1 Differential Encoding

The output from the MUX, burst, is a binary {0, 1} bit sequence. This sequence is first mapped from the RTZ (Return to Zero) signal representation to a NRZ representation before being input to the GMSK-modulator. This task is accomplished by the function diff_enc.m. GSM makes use of the following combined differential encoding and level shifting scheme, Where d[n] = (0, 1) and a[n] = (-1, +1) represent input and output sequences, respectively [6].

$$d`[n] = d[n] \oplus d[n-1]$$

$$a[n] = 1 - 2 \cdot d`[n]$$

Where ⊕ denotes modulo 2 additions and modulating data value a[n] is input to the modulator. To avoid the start condition problem the GSM recommendation prescribes that an infinite length sequence of all ones are assumed to precede the burst to be processed.

4.2 Modulation

After the differential encoding of the information burst the signal is GMSK-modulated. This is implemented by the function gmsk_mod.m where a complex baseband representation of the modulated signal is obtained.

Figure 6. GMSK baseband modulator implementation.

From Fig. 6 it is seen that the symbol sequence, a[n], is convolved with g(t), which is a frequency pulse function, and then multiplied with Π(pi), resulting in the generation of the phase function Θ(t,ā). The resulting phase function is evaluated through Sine and Cosine to obtain the in-phase, I, and quadrature phase, Q, values returned by the function. The variables i and q are used to return the in-phase and the quadrature signals, respectively[6][11].

5. MOBILE CHANNEL

5.1 AWGN Channel

The AWGN Channel block adds white Gaussian noise to a real or complex input signal. When the input signal is real, this block adds real Gaussian noise and produces a real output signal. When the input signal is complex, this block adds complex Gaussian noise and produces a complex output signal. This AWGN block in Matlab inherits its sample time from the input signal. In the simulation awgn function is used to add noise to the GMSK modulated signal. The syntax used is given by y = awgn(x, snr, 'measured'), which adds white Gaussian noise to the vector signal x. The scalar snr specifies the signal-to-noise ratio per sample, in dB. If x is complex, then AWGN adds complex noise. This syntax measures the power of x before adding noise to the signal.

5.2 Fading Channel

In the simulation, Rayleigh fading channel (RF) is used which acts as a linear FIR filter. Rayleigh fading channel object is created using function rayleighchan which is modeled for one or more major reflected paths. Simulation is carried out by passing different parameter value of Doppler Shift (DS) to the function and analyzing the synchronization and detection of SCH burst.

6. SYNCHRONIZATION AND DETECTION OF SCH-BURST

The receiver receives sampled signal r as an input. The first part in the receiver structure is to synchronize and detect the synchronization burst which is obtained by correlation method using the 64 bit TRAINING sequence as reference, since 64 bit TRAINING sequence is common for transmitter and receiver. The detection of SCH burst in Matlab is obtained by evaluating cross correlation between received burst and reference predefined TRAINING sequence. This is implemented by function corel_iq.m. The correlated value will be maximum for 64 bit TRAINING sequence. A predefined threshold level is set to obtain the detection of SCH-burst depending upon the signal to noise ratio. Once the detection of SCH-burst is done then the demodulation and decoding is carried out to obtain the timing information such as Frame number and Base Station Identity Code (BSIC) for time synchronization in wireless telecommunication.

7. SIMULATION RESULTS

To test the operation of the implemented SCH-burst transmitter and receiver time domain tests are carried out. The detection of SCH burst for I and Q signals are obtained from correlation method. The correlation value is maximum for the central 64 bit training sequence. When the correlated signal value crosses a predefined threshold value which is set at optimum level between 60 to 75, it indicates the detection of SCH-burst. The results are shown in Figure 13 and 14 for SNR equal to 10 dB. Similarly simulation is carried out by varying SNR and thus detection of SCH burst is possible when SNR set to as low as 1.2dB as described in the result analysis table 1.

The simulation results are carried out using Rayleigh Fading (RF) Channel with Doppler Shift (DS) as a parameter along with varying SNR. The detection of SCH-burst with SNR of 10 dB and Doppler Shift of 1Hz are shown in the Figure 15 and 16. Thus detection of SCH burst is possible with MS (user) travelling at a velocity of 60 Km/hr with corresponding Doppler Shift of 50Hz. More detail summary of simulation results are given in table 2.

7.1.1 Synchronization burst generation

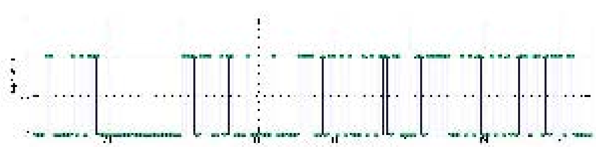

Figure 7. Synchronization burst generation.

7.1.2 Differentially encoded SCH-burst data

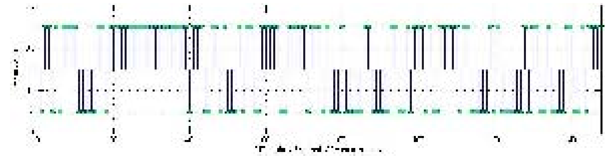

Figure 8. differentially encoded data.

7.1.3 Generation of Baseband signal- I

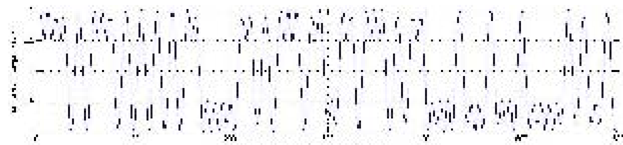

Figure 9. Baseband Signal I.

7.1.4 Generation of Baseband signal –Q

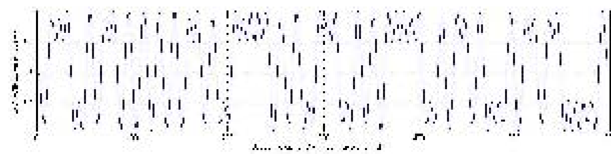

Figure 10. Baseband Signal Q.

7.1.5 Baseband signal-I with SNR=10dB

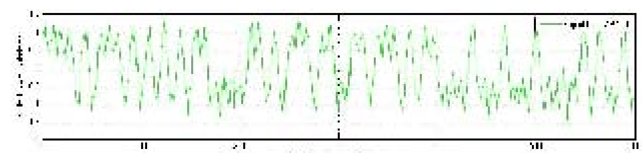

Figure 11. Baseband Signal I with SNR=10dB.

7.1.6 Baseband signal-Q with SNR=10dB

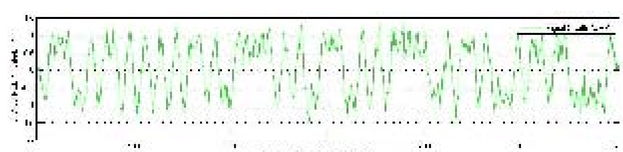

Figure 12. Baseband Signal Q with SNR=10dB

7.1.7 Detection of SCH burst(I) with SNR=10dB

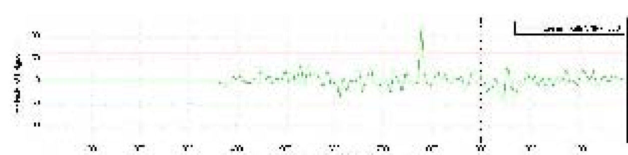

Figure 13. Detection of SCH burst (I) with SNR=10dB.

7.1.8 Detection of SCH-burst(Q) with SNR=10dB

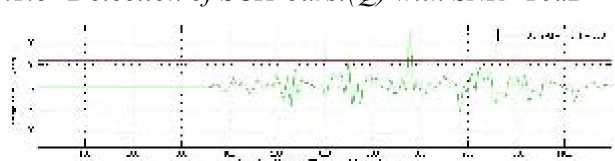

Figure 14. Detection of SCH burst (Q) with SNR=10dB

7.1.9 Detection of SCH-burst(I) with Rayleigh Fading (DS=1Hz,SNR=10dB)

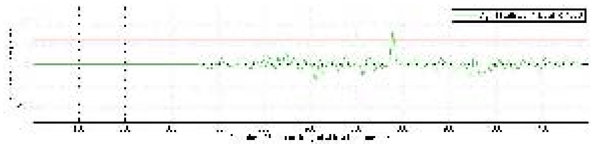

Figure 15. Detection of SCH burst (I) with Fading.

7.1.10 Detection of SCH-burst(Q) with Rayleigh Fading (DS=1Hz,SNR=10dB)

Figure 16. Detection of SCH burst (Q) with Fading.

Table 1. Result Summary for AWGN Channel

Threshold Level Set to: 60							
SNR(dB)	30	20	10	5	1.4	1.3	1.2
Detection of SCH-burst	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 2. Result Summary for Rayleigh Fading Channel

Threshold Level Set to: 60		
SNR = 30 dB, Carrier Frequency = 900 MHz		
Velocity (Km/hr)	**Doppler Shift(Hz)**	**Detection of SCH-burst**
0.0001188	0.0001	Yes
1.8	1	Yes
2.4	2	Yes
5.7	5	Yes
12	10	Yes
18	15	Yes
24	20	Yes
36	30	Yes
42	35	Yes
48	40	Yes
49	41	Yes
54	45	Yes
60	50	Yes

8. CONCLUSION

Synchronization burst detection is obtained with the use of Cross-correlation function, where 64 bit training sequence is used as a reference. The SCH-burst will have maximum peak value for the training sequence since training sequence is a fixed sequence that is transmitted by the transmitter and hence known at the receiver. From the simulation result summary shown in Table 1, it can be concluded that SCH burst can be detected with AWGN noise having SNR as low as 1.2dB which is within the GSM specification. Use of Rayleigh fading channel object along with AWGN noise having SNR of 30dB, SCH burst can be detected and timing information can be obtained with maximum Doppler Shift (DS) of 50Hz as seen from the Table 2. For a GSM carrier frequency of 900MHz, SCH-burst detection is possible for an MS(user) travelling at a velocity of 60km/hr and a corresponding Doppler Shift of 50Hz. Simulation result is also carried out for SNR set to 10dB and thus it is observed that detection is possible for maximum Doppler Shift of 45Hz. Thus the result obtained for SCH-burst detection without any errors are within the GSM specification.

9. ACKNOWLEDGMENT

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