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# ENHANCING THE GSM VOICE CAPACITY USING ORTHOGONAL SUB CHANNEL (OSC) TECHNIQUE IN DOWNLINK TRANSMISSION

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**ABSTRACT**

This paper presents a study of the voice services usage over Adaptive Multi-user channels on One Slot (VAMOS) for improving the voice capacity. VAMOS is an extension of the Global System for Mobile Communications (GSM) standard to enable the transmission of two GSM voice streams on the same radio resource using Orthogonal Sub Channel (OSC) technique for doubling the number of users served by one cell. The concept of VAMOS is based on multiplexing two or more users at one time slot. Therefore, it is a subject for this paper to consider the downlink transmission of GSM VAMOS systems. In this paper the feed forward transversal filter estimator is used for channel estimation. Furthermore, different values for Alpha in Alpha QPSK modulation are used to notice the performance of VAMOS system. In the downlink at each mobile station the channel coefficients and the sub-channel power imbalance ratio (SCPIR) are estimated.

**General Terms:** Improving voice capacity for GSM networks.



## INTRODUCTION

During the last decades, the world has seen significant changes in the telecommunications industries (Garg, 2007) GSM network is seeing the greatest expansion because of the growing demand inthe mobile voice services recently. Many proposed technologies, would help operators in densely populated cities to alleviate the strain on their networks.Multi-User Reusing One Slot (MUROS) technology was proposed for this purpose. The concept of MUROS is based on multiplexing two or more users onto one time slot without degrading the speech quality. One solution of MUROSis orthogonal sub channel (OSC). For the downlink (DL) OSC, there are training sequence codes (TSCs) which are low cross-correlated with legacy TSCs.

### The Concept of Vamos

In the GSM network each carrier frequency is divided into eight time slotsas shown in Fig. 1 and each time slot is specific for only one user as shown in Fig. 2(a) to transmit its burst. This is from the properties of time-division multiple accesses (TDMA). The concept of VAMOS provides two or more users allocated on the same radio resource, i.e. the same time sloton the same carrier frequency, as shown in Fig. 2(b) which sometimes is known as MUROS. Each user occupies one orthogonal sub-channel. The MUROS user's signals are mixed together and the receivers can recognize them by low cross correlation training sequence codes (TSCs), (Chen, 2008).

### System Model

We consider the downlink of a VAMOS system with Orthogonal Sub Channel (OSC).Two mobile stations transmit voice stream in the same time slot and frequency. At each mobile station the sequences of information carrying bits is divided into classes of data (Molteni and Nicoli, 2013). The block diagram of the transmitter, channel and the receiver in the case of one user is shown in Fig. 3. The first block is channel coded with a convolutional encoder with a coding rate $R_C = \frac{1}{2}$ and constraint length is 5 after that the encoded data is interleaved over four burst. All these steps are repeated for the second user then the normal burst from user one and user two interleaved together and generate one normal burst. Then, the bits in the final normal burst are mapped using Alpha QPSK modulation (AQPSK). The received signal is added by additive white Gaussian noise (AWGN) and Co-Channel Interference (CCI) which is n(k) and q(k) respectively (Ruder, 2014). All the steps in the transmitter of VAMOS system can be shown in Fig. 4.

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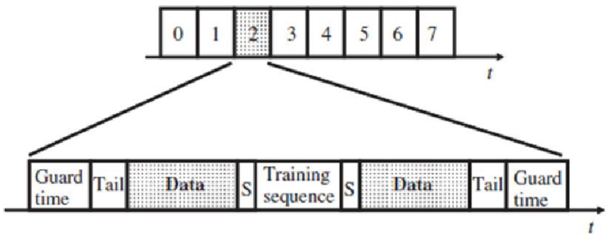
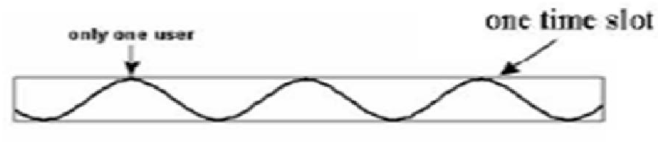
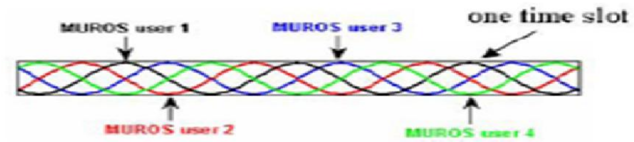



**Figure 1. A GSM burst (Sauter, 2011)**




(a) One user occupies one time slot




(b)Multi-user multiplexing on one time slot

**Figure 2. VAMOS concept description (Chen, 2008)**

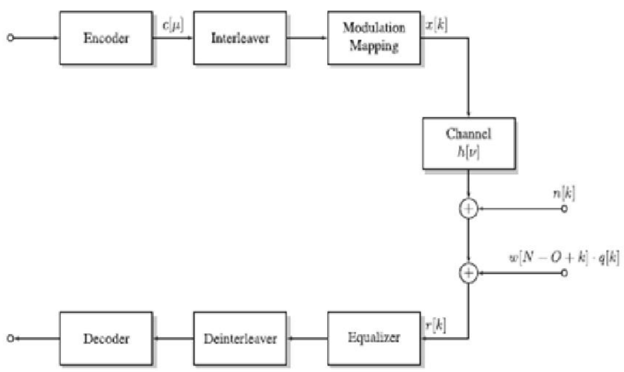



**Figure 3. Block diagram of transmitter, channel and receiver (Ruder, 2014)**

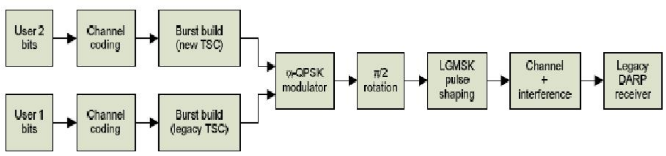



**Figure 4.Block diagram of the transmitter in VAMOS (GPP, 2009)**

## Normal burst (NB)

The normal burst is used to transmit information on traffic and control channels. At the start and end of each burst are three tail bits which are always set to logical '0'. The stealing flags (SF) are signaling bits which indicate whether the burst contains traffic data or signaling data. They are set to allow use of single time slots of the traffic channel (TCH) in preemptive multiplexing mode e.g. when during thehandover. In the GSM, thehandover is to transfer the existing voice connection to a new base station and handover may made by the network not by the mobile station. In this case, a fast transmission of signaling data on the FACCH is needed. These causes a loss of user data may happen i.e. these time slots are stolen from the traffic channel hence the name stealing flag. A normal burst contains besides the synchronization and signaling bits as shown in Fig 5. Two blocks of 57 bits each of error protected and channel coded user data separated by a 26 bits midamble. This midamble consists of predefined known bit patterns the training sequences which are used for channel estimation to optimize reception with an equalizer and for synchronization with the help of these training sequences the equalizer eliminates or reduces the intersymbol interferences which are caused by propagation time differences of the multipath propagation (Eberspächer and Vögel, 2001).

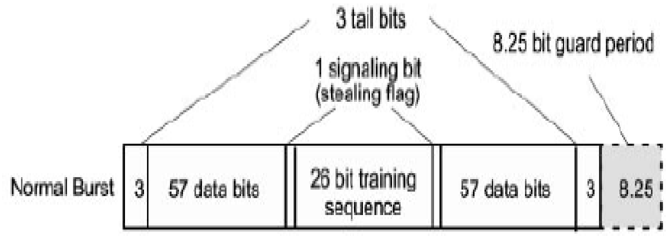



**Figure 5. Normal burst (Eberspächer and Vögel, 2001)**

Eight different training sequences are defined for the normal burst for each user in VAMOSsystem as shown in Table 1. Which are designed by the training sequences code (TSC). For example if user one in VAMOS system uses the training sequences code (TSC) number 2 from the first TSC set then user two should use TSC number 2 from the second set of the training sequences code (TSCs)because the training sequences code (TSC) with the same number were designed with very good cross correlation properties. The training sequences code (TSC) are not only used for channel estimation but are also used for other purposes for which an a prior knowledge about the transmitted data is beneficial e.g. synchronization (Ruder, 2014). Actually each time slot (burst) consists of the GSM burst and the guard band and isthus 156.25 bits long and takes up 577 µs, with each single bit taking approximately3.69 µs. Note that the guard band consisting of 8.25 bits is only used as a time interval (approximately 30 µs) between time slots to separate one user transmission fromthe next (Bannister, 2004).

## Downlink transmission with Alpha QPSK Modulation

VAMOS uses Alpha QPSK as the downlink modulation algorithm. The composite baseband signal is generated by multiplexing two user signals with orthogonal training sequences code (TSC) onto one baseband signal employing a quaternary modulation scheme. On the receiver side, the signal detection applying the known training sequence indexed by the user-specific Training Sequence Code is executed. Fig. 6 depicts the baseband transmitter in downlink using the OSC technique. The data from user *A* and user *B* are mapped onto AQPSK constellations where for each constellation symbol, the first bit is assigned to user A, in the first sub-channel OSC *A*, and the second bit is assigned to user *B*, in the second sub-channel OSC *B*. Since the signal constellations are based on AQPSK modulation such as ordinary QPSK when Alpha = 1in this case the orthogonal sub channels are transmitted with equal power, that is the I and Q branches have the same power (Säily, 2010).

**Table 1. First TSC set (TSC Set 1) is applied to the first sub-channel and second TSC set (TSC Set 2) is applied to the second sub-channel (Säily, 2010)**

| Training Sequence Code (TSC) | Training sequence bits for TSC Set 1 |
|---|---|
| 0 | (0,0,1,0,0,1,0,1,1,1,0,0,0,0,1,0,0,0,1,0,0,1,0,1,1,1) |
| 1 | (0,0,1,0,1,1,0,1,1,1,0,1,1,1,1,0,0,0,1,0,1,1,0,1,1,1) |
| 2 | (0,1,0,0,0,0,1,1,1,0,1,1,1,0,1,0,0,1,0,0,0,0,1,1,1,0) |
| 3 | (0,1,0,0,0,1,1,1,1,0,1,1,0,1,0,0,0,1,0,0,0,1,1,1,1,0) |
| 4 | (0,0,0,1,1,0,1,0,1,1,1,0,0,1,0,0,0,0,0,1,1,0,1,0,1,1) |
| 5 | (0,1,0,0,1,1,1,0,1,0,1,1,0,0,0,0,0,1,0,0,1,1,1,0,1,0) |
| 6 | (1,0,1,0,0,1,1,1,1,1,0,1,1,0,0,0,1,0,1,0,0,1,1,1,1,1) |
| 7 | (1,1,1,0,1,1,1,1,0,0,0,1,0,0,1,0,1,1,1,0,1,1,1,1,0,0) |
| | **Training sequence bits for TSC Set 2** |
| 0 | (0,1,1,0,0,0,1,0,0,0,1,0,0,1,0,0,1,1,1,1,0,1,0,1,1,1) |
| 1 | (0,1,0,1,1,1,1,0,1,0,0,1,1,0,1,1,1,0,1,1,1,0,0,0,0,1) |
| 2 | (0,1,0,0,0,0,0,1,0,1,1,0,0,0,1,1,1,0,1,1,1,0,1,1,0,0) |
| 3 | (0,0,1,0,1,1,0,1,1,1,0,1,1,1,0,0,1,1,1,1,0,1,0,0,0,0) |
| 4 | (0,1,1,1,0,1,0,0,1,1,1,1,0,1,0,0,1,1,1,0,1,1,1,1,1,0) |
| 5 | (0,1,0,0,0,0,0,1,0,0,1,1,0,1,0,1,0,0,1,1,1,1,0,0,1,1) |
| 6 | (0,0,0,1,0,0,0,0,1,1,0,1,0,0,0,0,1,1,0,1,1,1,0,1,0,1) |
| 7 | (0,1,0,0,0,1,0,1,1,1,0,0,1,1,1,1,1,1,0,0,1,0,1,0,0,1) |

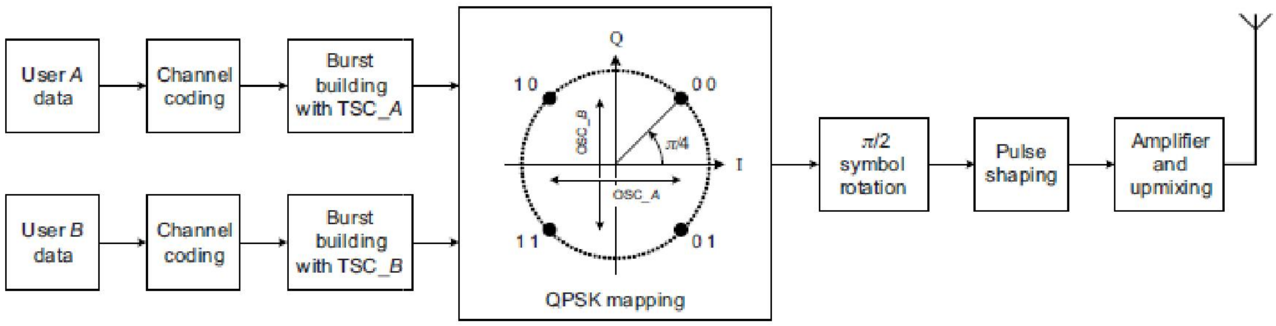



**Figure 6. Baseband transmitter block diagram for orthogonal sub-channels technique[10].**

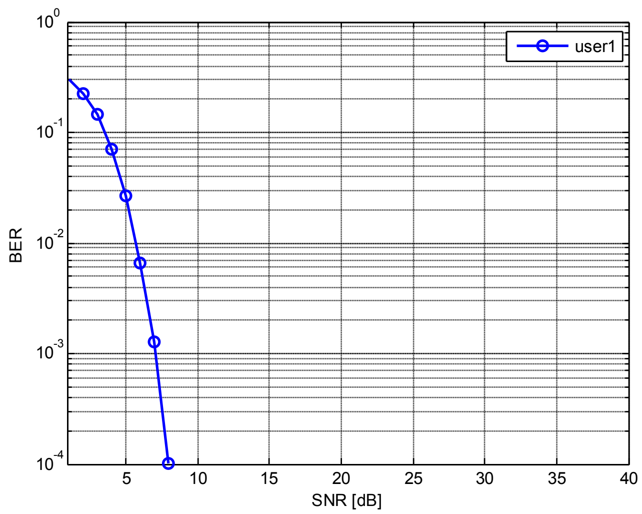



**Figure 7. BER Performance for estimation with Alpha = 1 for user 1**

## SIMULATION AND RESULTS

First of all, the simulation run for the VAMOS system is applied by feedinga forward transversal filter estimatorfor channel estimation.

Simulations are carried out for different signal-to-noise (SNR) ratios and for different values of Alpha since the aim is to observe channel estimation performance. The multi-path fading channel model used in the simulation is Rayleigh fading.

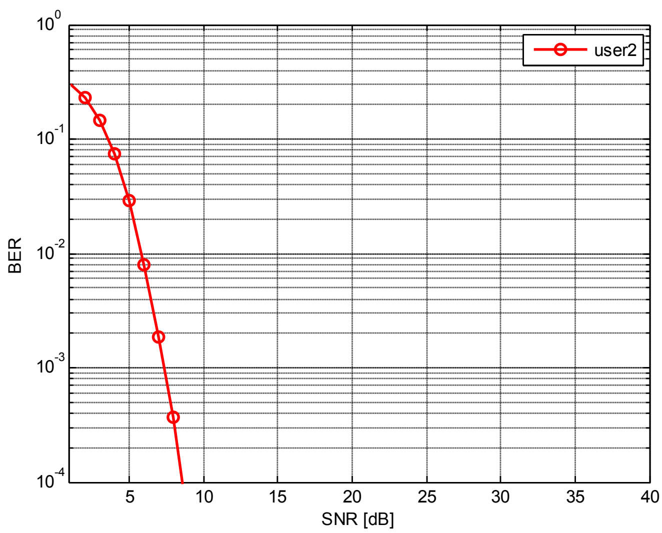



**Figure 8. BER performance for estimation with Alpha=1 for user 2**

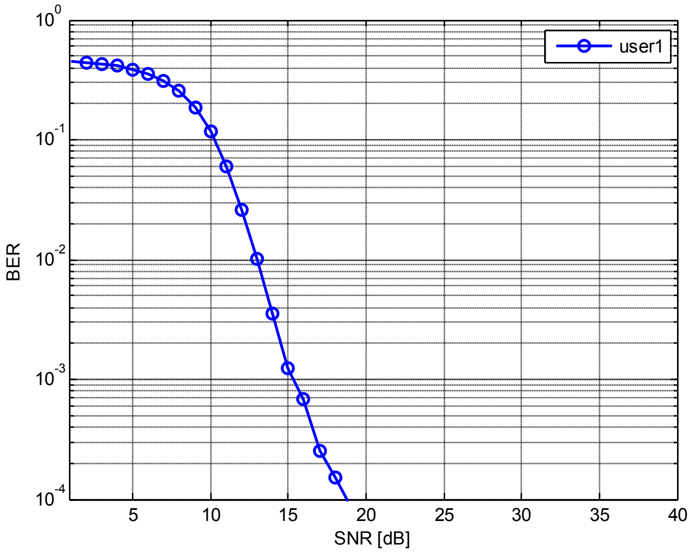



**Figure 9. BER performance for estimation with Alpha=0.5 for user 1**

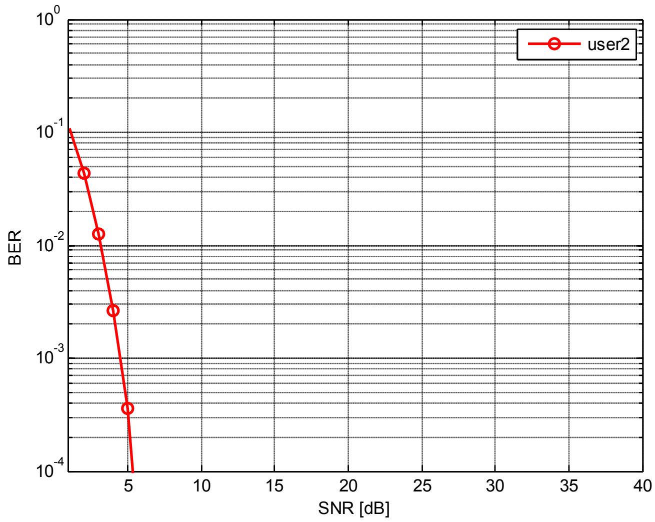



**Figure 10. BER performance for estimation with Alpha=0.5 for user 2.**

It is obvious in Fig.7and Fig. 8 when Alpha = 1 the BER decrease with increase SNR for user 1 (blue line) and user 2 (red line). It is noticed in Fig.9 and Fig. 10 that when Alpha = 0.5 this also minimize the BER of this estimator. From BER performance offeredfeed forward transversal filter channel estimation, it is obvious that the BER offeed forward transversal filter estimator for user 1 (blue line) when Alpha = 1 is better than the BER offeed forward transversal filter estimator for user 1 (blue line) when Alpha = 0.5 by about (10 dB) in Fig.7and Fig. 9. From BER performance offered feed forward transversal filter channel estimation, it is obvious that the BER offeed forward transversal filter estimator for user 2 (red line) when Alpha = 1 is worse than the BER offeed forward transversal filter estimator for user 2 (red line) when Alpha = 0.5 by about (3 dB) in Fig. 8 and Fig. 10.

**Conclusion**

In this paper, the feed forward transversal filter estimatorhas been used for channel estimationin VAMOS system. By applying the use of different values for Alpha in Alpha QPSK modulation, it is noticedthat when Alpha = 1 and Alpha = 0.5 the BER of this estimator decreases with increasingthe SNR for user 1 (blue line) and user 2 (red line). From BER performance offered feed forward transversal filter channel estimation, it is obvious that the BER offeed forward transversal filter estimator for user 1 (blue line) when Alpha = 1 is better than the BER offeed forward transversal filter estimator for user 1 (blue line) when Alpha = 0.5 by about (10 dB) in Fig.7and Fig. 9. From BER performance offered feed forward transversal filter channel estimation, it is obvious that the BER offeed forward transversal filter estimator for user 2 (red line) when Alpha = 1 is worse than the BER offeed forward transversal filter estimator for user 2 (red line) when Alpha = 0.5 by about (3 dB) in Fig. 8 and Fig. 10. It can be seen that when Alpha in Alpha QPSK modulation changes the power in the I and Q branch of a quaternary constellation for user 1 and user 2 are changed and effect on the BER performance of VAMOS system. So the Alpha value reflects the power ratio between the two users and takes any value between 0 and $\sqrt{2}$ .

**Acknowledgments**

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