An Overview on FHSS Technique with Simulation

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ABSTRACT

In This paper we analyze the problems of a frequency hopping spread spectrum (FHSS) and deals with properties and utilization to bring the technique in practice . FHSS is a radio transmission process where user information is sent on a radio channel that regularly changes frequency according to a predetermined code. The FHSS technique is useful for suppressing interference, making interception difficult, accommodating fading and multipath channels, and providing a multiple-access to user. The receiver demodulates the received signal by the carrier frequencies that change synchronously depending on the same frequency hopping sequence and makes a detection of it. Contemporary frequency hopping systems use either noncoherent or differentially coherent demodulators. this paper, also provides simulation procedure of a fast frequency hopping/binary frequency shift keying (FFH/BFSK) spread spectrum system in MATLAB is described.

Keyword: *MATLAB, FDMA, MFSK, SPREAD SPECTRUM.*

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1. INTRODUCTION

In wireless communication systems it is often desirable to allow the subscriber to send simultaneously information to the base station while receiving information from the base station. A cellular system divides any given area into cells where a mobile unit in each cell communicates with a base station. The main aim in the cellular system design is to be able to increase the capacity of the channel i.e. to handle as many callsas possible in a given bandwidth with a sufficient level of quality of service. There are several different ways to allow access to the channel. These include mainly the following:
1) Frequency division multiple-access (FDMA)
2) Time division multiple-access (TDMA)
3) Code division multiple-access (CDMA)
4) Space Division multiple access (SDMA)
FDMA, TDMA and CDMA are the three major multiple access techniques that are used to share the available bandwidth in a wireless communication system. Depending on how the available bandwidth is allocated to the users these techniques can be classified as narrowband and wideband systems.

1.1 Narrowband Systems

The term narrowband is used to relate the bandwidth of the single channel to the expected coherence bandwidth of the channel. The available spectrum is divided in to a large number of narrowband channels. The channels are operated using FDD. In narrow band FDMA, a user is assigned a particular channel which is not shared by other users in the vicinity and if FDD is used then the system is called FDMA/FDD. Narrow band TDMA allows users to use the same channel but allocated a unique time slot to each user on the channel, thus separating a small number of users in time on a single channel. For narrow band TDMA, there generally are a large number of channels allocated using either FDD or TDD, each channel is shared using TDMA. Such systems are called TDMA/FDD and TDMA/TDD access systems.

1.2 Wideband System

In wideband systems, the transmission bandwidth of a single channel is much larger than the coherence bandwidth of the channel. Thus, multipath fading doesn't greatly affect the received signal within a wideband channel, and frequency selective fades occur only in a small fraction of the signal bandwidth.

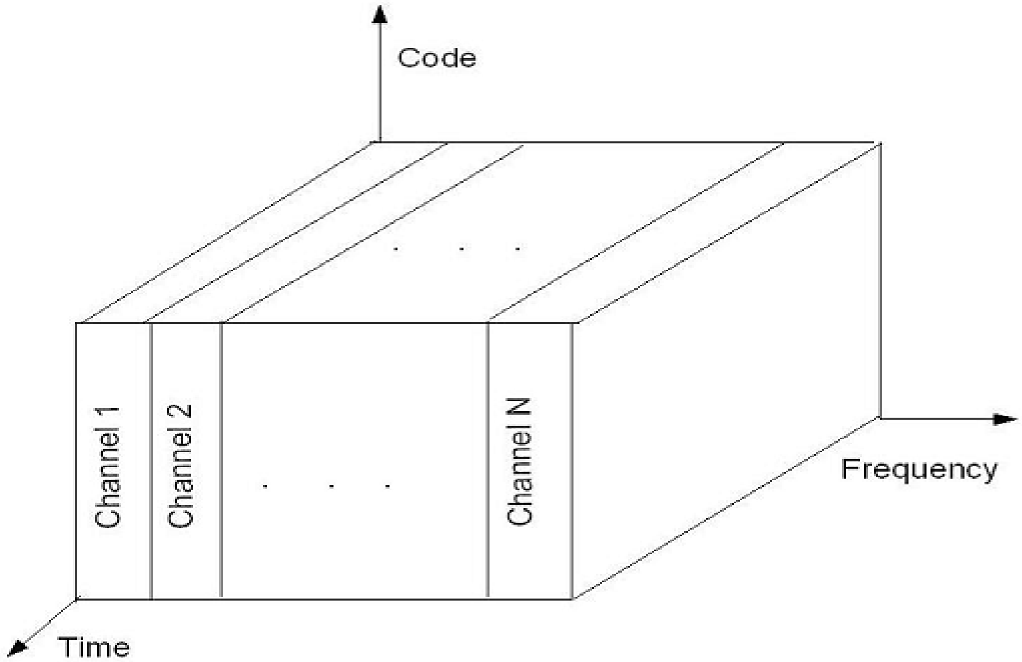

Figure 1: The basic concept of FDMA.

1.3 Frequency Division Multiple Access

This was the initial multiple-access technique for cellular systems in which each individual user is assigned a pair of frequencies while making or receiving a call as shown in Figure 8.1. One frequency is used for downlink and one pair for uplink. This is called frequency division duplexing (FDD). That allocated frequency pair is not used in the same cell or adjacent cells during the call so as to reduce the co channel interference. Even though the user may not be talking, the spectrum cannot be reassigned as long as a call is in place. Different users can use the same frequency in the same cell except that they must transmit at different times.

1.6 FDMA/FDD in AMPS

The first U.S. analog cellular system, AMPS (Advanced Mobile Phone System) is based on FDMA/FDD. A single user occupies a single channel while the call is in progress, and the single channel is actually two simplex channels which are frequency duplexed with a 45 MHz split. When a call is completed or when a handoff occurs the channel is vacated so that another mobile subscriber may use it. Multiple or simultaneous users are accommodated in AMPS by giving each user a unique signal. Voice signals are sent on the forward channel from the base station to the mobile unit, and on the reverse channel from the mobile unit to the base station. In AMPS, analog narrowband frequency modulation (NBFM) is used to modulate the carrier.

1.5 FDMA/TDD in CT2

Using FDMA, CT2 system splits the available bandwidth into radio channels in the assigned frequency domain. In the initial call setup, the handset scans the available channels and locks on to an unoccupied channel for the duration of the call. Using TDD(Time Division Duplexing), the call is split into time blocks that alternate between transmitting and receiving.

1.6 Time Division Multiple Access

In digital systems, continuous transmission is not required because users do not use the allotted bandwidth all the time. In such cases, TDMA is a complimentary access technique to FDMA. Global Systems for Mobile communications (GSM) uses the TDMA technique. In TDMA, the entire bandwidth is available to the user but only for a finite period of time. In most cases the available bandwidth is divided into fewer channels compared to FDMA and the users are allotted time slots during which they have the entire channel bandwidth at their disposal

2. INTRODUCTION TO HOPPING

The type of spread spectrum in which the carrier hops randomly from one frequency to another is called a frequency hopping spread spectrum (FHSS) Frequency hopping was first used for military electronic countermeasures, because the transmitted signal that uses frequency hopping is difficult to detect and monitor. In an FHSS system the signal frequency is constant for specified time duration, referred to as a hop period Th
. The hop period is the time spent in transmitting a signal in a particular frequency slot of bandwidth $B \ll W$, where W and B are spread and symbol bandwidth, respectively. The sequence of carrier frequencies is called the frequency hopping pattern. The set of L possible carrier frequencies $\{f1, f2, \ldots, fL\}$ is called the hopset. The rate at which the carrier frequency changes is called the hop rate Rh. The carrier frequencies are changed periodically. Hopping occurs over a frequency band called the hopping band that includes L frequency channels. This hopping is typically done in a pseudo-random manner. Each frequency channel is defined as a spectral region that includes a single carrier frequency of the hopset as its center frequency and has a bandwidth B large enough to include most of the power in a signal pulse with a specific carrier frequency. Fig. 1 [6] illustrates the frequency channels associated with a particular frequency hopping pattern. Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work.

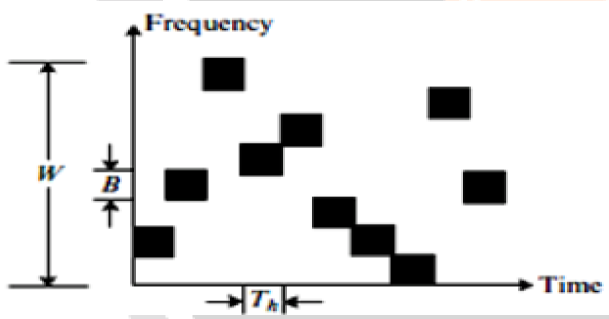

Figure 2: Frequency hopping patterns

3. Description of an FH/MFSK Spread Spectrum System

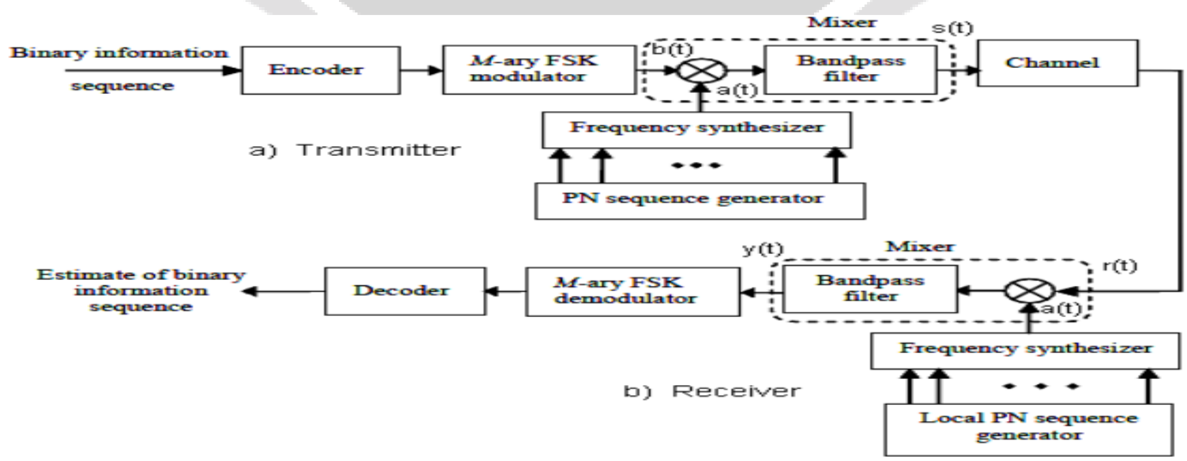

Figure 3: Block diagram of an FH/MFSK spread spectrum system. a) Transmitter; b) Receiver

First, the incoming binary data are applied to an M-ary FSK modulator. For M-ary FSK, the data signal (real bandpass signal) can be expressed as [7]

$$b(t) = \sqrt{2P} \sum_{k=\infty}^{\infty} pTs(t - kTs) \cos(\omega kt + \phi k)$$

where $\omega k \in \{\omega s0, \omega s1, \dots, \omega sM{-}1\}$. The frequency synthesizer outputs a hopping signal

$$a(t) = 2 \sum_{k=\infty}^{\infty} pTc(t - lTc) \cos(\omega l\,'t + \phi l\,')$$

where $p(t)$ is the pulse shape used for the hopping waveform, Tc is the hop period also called the chip period, $\omega l\,' \in \{\omega c0, \omega c1, \dots, \omega cL{-}1\}$ are the L hop frequencies, and $\phi l\,'$ are the phases of each oscillator. The resulting modulated wave and the output from a digital frequency synthesizer generating a signal with a frequency among a predefined set of possible frequencies are then applied to a mixer that consists of a multiplier followed by a bandpass filter (BPF). The resulting frequency hopped transmit signal is then
$s(t) = [b(t)a(t)]BPF$.

3.SLOW AND FAST HOPPING FHSSITLE

3.1 Description of Slow Frequency Hopping

First, let us consider the case where $Tc > Ts$, which is called slow frequency hopping. A slow FH/MFSK signal is characterized by having multiple symbols transmitted per hop. Hence, each symbol of a slow FH/MFSK signal is a chip. We impose the constraint that $Tc = NT\,s$ for slow frequency hopping. For the case of slow frequency hopping, the FHSS signal is given by [7]

$$s(t) = \sqrt{2P} \sum_{k=\infty}^{\infty} pTs(t - kTs - \Delta) \cos\left[(\omega k + \omega)(t - \Delta) + \phi k + \phi \left\lfloor {}^{k}/_{N} \right\rfloor\right]$$

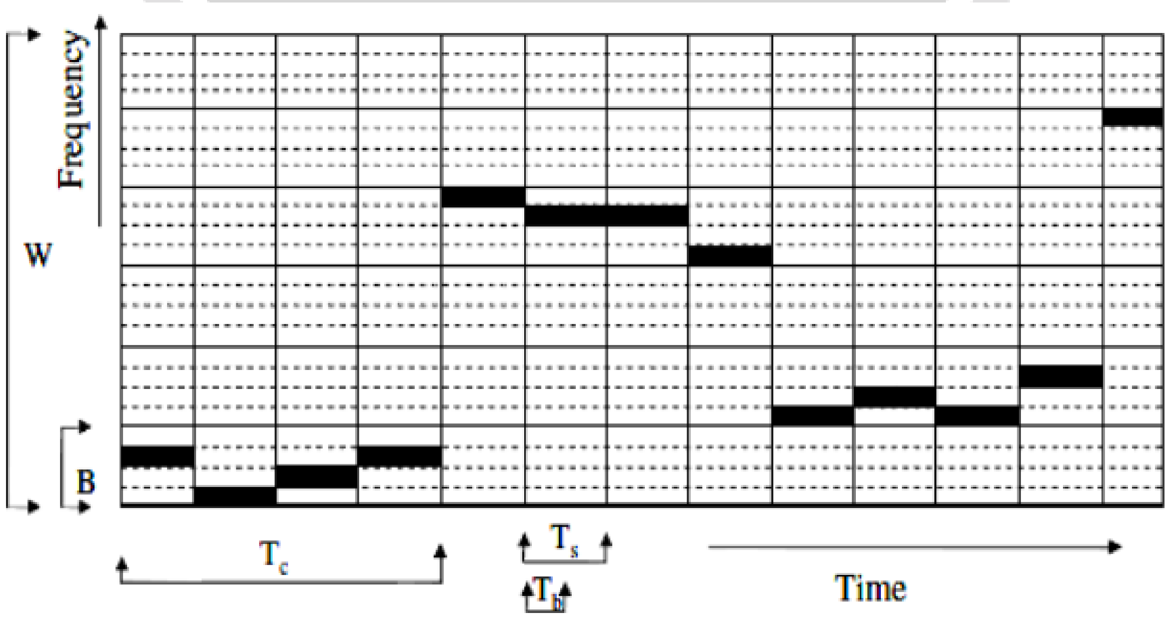

Figure 4: Time-frequency plot for slow frequency hopping (Tc = hop period, Ts = symbol period, Tb = bit period, W = spread bandwidth, B = symbol bandwidth)

3.1 Flow chart

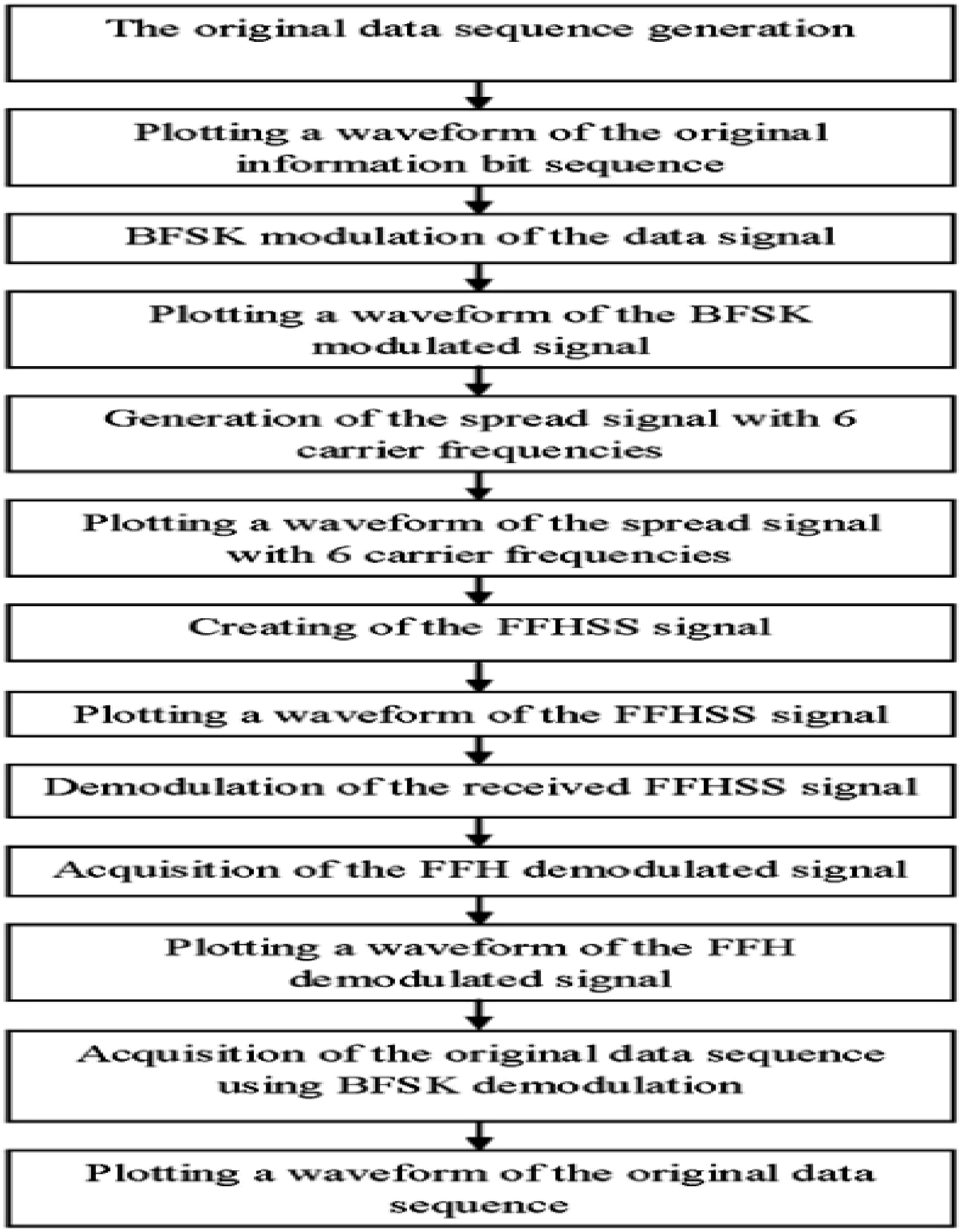

Figure 5: Flow chart of the MATLAB simulation procedure of a FFH/BFSK spread spectrum system

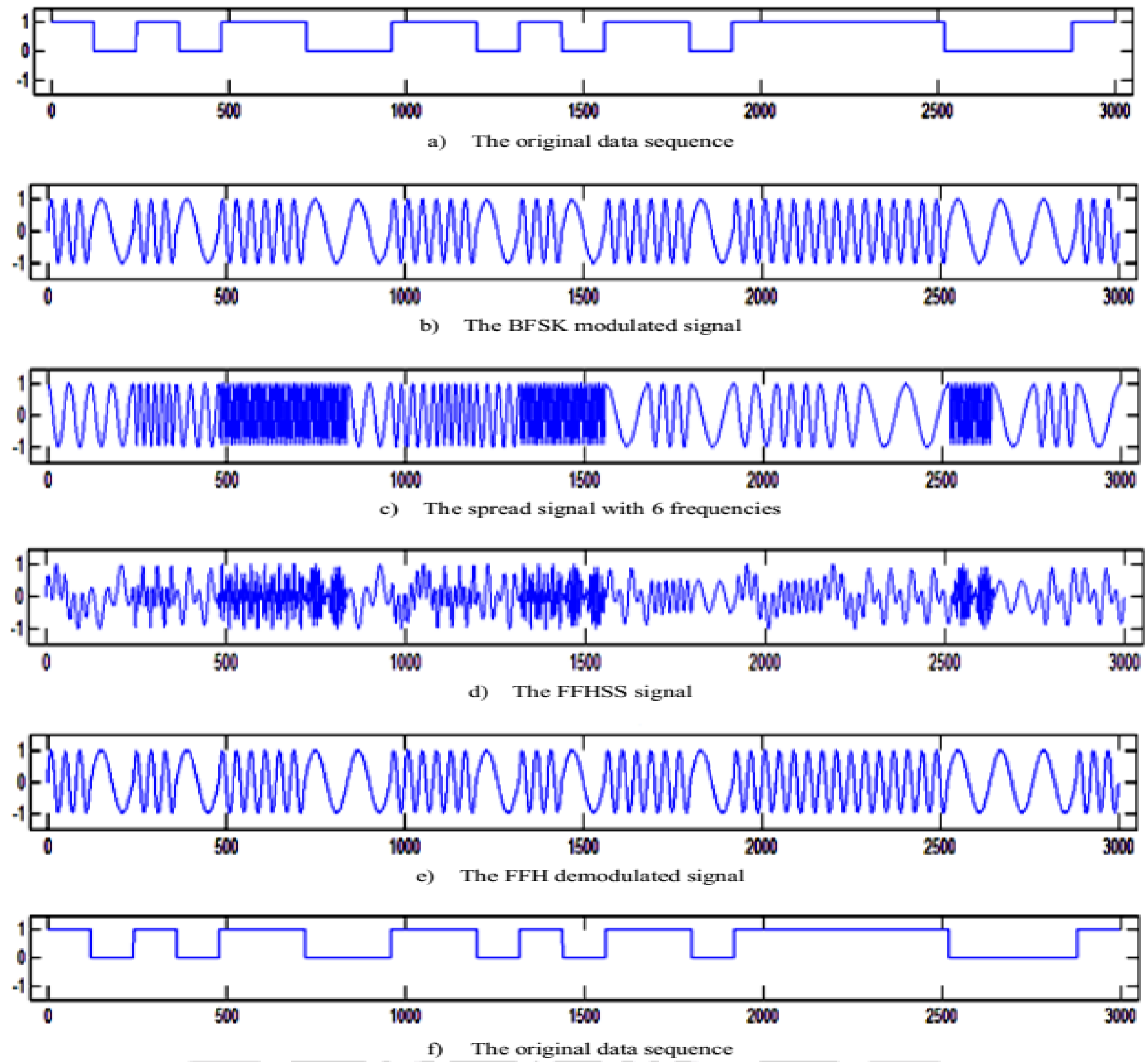

Figure 6: The simulation results of an FFH/BFSK spread spectrum system in MATLAB

4. CONCLUSIONS

In this paper, we have presented FHSS signals and finally, we have described a simulation procedure of an FFH/BFSK spread spectrum communication system in MATLAB. Consequently we have mathematically described signals in an FH/MFSK spread spectrum communication system. This system is usually configured using noncoherent demodulation since frequency hopping technique operates over a wide bandwidth and it is difficult to maintain phase coherence from hop to hop. In the next section of this paper, we have discussed slow frequency hopping and fast frequency hopping symbol. It have frequency diversity at the symbol level, which provides a substantial benefit in fading channels or versus narrowband jamming. On the other hand, slow frequency hopping can obtain these same benefits through error correction coding, but fast hopping offers this benefit before coding, which can provide better performance. Here we compare both type of hopping on analysis and simulation basis.

5. REFERENCES

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BIOGRAPHIES

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