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Enhanced Performance Analysis of OFDM, Measuring Bit Error Rate and Peak to Average Power Ratio using Different Modulation

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Abstract**—**Wireless communications is the fastest growing segment of the communication industry. The most common used wireless communication is mobile communication. But, there are many technical challenges that must be overcome. In A signal transmitted on a wireless channel is subject to Interference, Fading, Propagation path loss, Shadowing etc. There is always a greater order for capacity with the high quality service. In this situation, OFDM is well defined technique, which is a very much suitable option for high band width data transmission, by converting the wideband signal into narrow band signals for transmission. The transmission of these individual narrow band signals are executed with orthogonal carrier. In this dissertation, the performance of transmission mode are evaluated by Bit Error Rate versus the Signal to Noise Ratio under frequently used Rayleigh channel modes,. In order to investigate, first we derive the mathematical modeling for bit error rate and signal to noise ratio of OFDM over Rayleigh then, OFDM is design. now we have assumed Rayleigh fading channel as noise channel and also built BPSK, QPSK and QAM modulation technique. OFDM transmitters and receivers are implemented here using IFFT and FFT of size 64 with 52 sub carriers to convert the spectra to time domain & vice versa and also measure peak to average power ratio in different modulation scheme.

Keywords**—**PAPR, Digital Audio Broadcasting (DAB) ,(OFDM) orthogonal frequency division multiplexing ,MIMO ,Low Density Parity check(LDPC) and Complementary cumulative distribution function(CCDF) ,Digital amplitude modulation (DAM), ACLR,OOB

I. INTRODUCTION

In recent years orthogonal frequency division multiplexing (OFDM) has gained a lot of involvement in diverse digital communication applications. It is a new ensuring transmission scheme for broadband communications over a wireless channel. In OFDM data is transmitted simultaneously through multiple frequency bands . It offers many advantages over single frequency transmission such as high spectral efficiency, robustness to channel fading, immunity to impulse interference, and the capability to handle frequency-selective fading without resorting to complex channel equalization schemes. OFDM also uses small guard interval, and its ability to combat the ISI problem. So, simple channel equalization is needed instead of complex adaptive channel equalization. In the conventional serial data transmission system, the information symbols are transmitted sequentially where each symbol occupies the entire available spectrum bandwidth. But in an OFDM system, the information is converted to N parallel sub-channels and sent at lower rates using frequency division multiplexing. The subcarrier frequency spacing is selected carefully such that each subcarrier is located on the other subcarriers zero crossing points [7]. This implies that there is overlapping among the subcarriers but will not interfere with each other, if they are sampled at the sub carrier frequencies. This means that all subcarriers are orthogonal. Due to the orthogonality of the subcarriers the transmission bandwidth is used efficiently as the subcarriers are allowed to overlap each other and still be decoded at the receiver. OFDM has been used for Digital Audio Broadcasting (DAB) and Digital Video Broadcasting (DVB) in Europe and for Asymmetric Digital Subscriber Line (ADSL) high data rate wired links. OFDM has also been standardized as the physical layer for the wireless networking standard 'HIPERLAN2' in Europe and as the IEEE 802.11a, g standard in the US, promising raw data rates of between 6 and 54Mbps.OFDM has various properties that make it desirable over existing single carrier systems, the main advantage is OFDM's immunity to frequency selective fading. As the name suggests, wireless systems operate via transmission through space rather than through a wired connection. This has the advantage of allowing users to make and receive calls almost anywhere, including while in motion. Wireless communication is sometimes called mobile communication since many of the new technical issues arise from motion of the transmitter or receiver. Since the mid-1990s, the cellular communications industry has witnessed explosive growth. Wireless communications networks have become much more pervasive than anyone could have imagined when the cellular concept was first developed in the 1960s and 1970s. As shown in Figure 1.1, the worldwide cellular and personal communication subscriber base surpassed 600 million users in late 2001, and the number of individual subscribers is projected to reach 2 billion (about 30% of the world's population) by the end of 2006.

Certainly, most countries throughout the world continue to experience cellular subscription increases of 40% or more per year. The widespread adoption of wireless communications was accelerated in the mid-1990s, when governments throughout the world provided increased competition and new radio spectrum licenses for personal communications services (PCS) in the 1800–2000 MHz frequency bands.

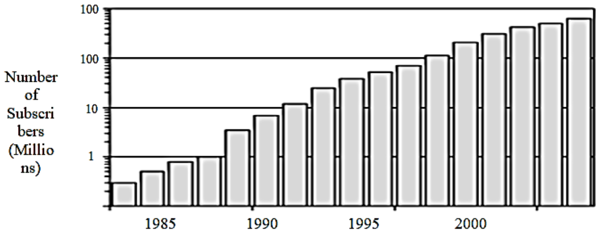

Figure1.1. Growth of cellular telephone subscribers throughout the world [27]

II. PROBLEM WITH WIRELESS COMMUNICATION SYSTEMS

There are two major problems to be addressed in wireless that do not arise with wires. The first is that the communication channel often varies with time. The second is that there is often interference between multiple users.In digital modulation, an analog carrier signal is modulated by a digital bit stream (discrete signal).Digital modulation methods can be considered as digital-to-analog conversion, and the corresponding demodulation or detection as analog-to-digital conversion. The changes in the carrier signal are chosen from a finite number of M alternative symbols (the modulation alphabet).

III. LITERATURE SURVEY

Vipin Kumar etal. Analyzed the performance of MIMO-OFDM system by using ASTC encoder. In this paper, they evaluated the performance of MIMO OFDM system under different modulation techniques. The performance of system is evaluated by calculating the probability of Bit Error Rate (BER) versus the Signal Noise Ratio (SNR) and Energy per bit to Noise power spectral density ratio under the Rayleigh fading channel [1].

Arun Agrawal et al. described OFDM based WiMAX (Worldwide Interoperability for Microwave Access) have been a promising last mile access technology to provide high speed internet access in the residential as well as small and medium sized enterprise sectors. OFDM-based WiMAX systems are capable to provide high data rate with low BER (bit error rate) at low SNR (signal to noise ratio)[2].

Ahmed A. Quadeer et al proposed a novel OFDM is ideally suited to deal with frequency selective channels and AWGN, its performance may be dramatically impacted by the presence of impulse noise. In fact, very strong noise impulses in the time domain might result in the erasure of whole OFDM blocks of symbols at the receiver. Impulse noise can be mitigated by considering it as a sparse signal in time, and using recently developed algorithms for sparse signal reconstruction[3].

Wadhwa et al. described BER analysis &comparison of different equalization techniques for MIMO-OFDM system. This paper provides the complete knowledge of the key issues in the field of mobile communication. The data transmission at high bit rate is essential for many services such as video, high quality audio and mobile integrated service digital network. When data is transmitted at high bit rates over mobile radio channels, the channel impulse response can extend over many symbol periods which leads to Inter symbol Interference. The ultimate goal of this paper is to provide universal personal and multimedia communication without regard to mobility or location with a high data rates [4].

Vishal et al. described the analysis of OFDM BER and PAPR with the help of turbo code. This paper described four typical techniques to reduce PAPR, all of which have the potential to provide substantial reduction inPAPR at the cost of loss in data rate, transmit signal power increase, BER performance degradation, computational complexity increase, and so on. [5].

Ligata et al. Implemented closed-form BER expressions for OFDM with CE based on both TDM and FDM pilots in a nonlinear and frequency-selective fading channel. This paper shows that the pilot-assisted CE with the FDM pilot is affected by the nonlinear noise due to both the quantization and the HPA, while the pilot-assisted CE with the TDM pilot is only affected by nonlinear degradation due to quantization because of the pilot-sequence with low PAPR. Thus, the higher BER with FDM pilot in comparison with TDM pilot is observed [6].

Dwivedietal. Suggested a simple ICI cancellation scheme to reduce the frequency offset sensitivity of the OFDM system which is based upon conjugate cancellation scheme. The objective of this paper is bit error rate (BER) analysis of the orthogonal frequency division multiplexing (OFDM) communication systems with the concept of conjugate cancellation scheme. In this scheme two sequences are transmitted in each data symbol. First sequence is original received sequence and another sequence is conjugate of the original sequence. Thus the transmitted two sequences are conjugate of each other rather than adjacent sub-carriers with opposite polarities in order to cancel ICI [7].

Coleri et al. Developed channel estimation techniques for OFDM systems based on pilot arrangement. In this paper, a full review of block-type and comb-type pilot based channel estimation is given. Channel estimation based on block-type pilot arrangement with or without decision feedback equalizer is described. Channel estimation based on comb-type pilot arrangement is presented by giving the channel estimation methods at the pilot frequencies and the interpolation of the channel at data frequencies [8].

PROBLEM STATEMENT

- Single carrier systems can increase their data rate by shortening the symbol time, thereby increasing the occupied bandwidth. Wideband channels are sensitive to frequency selective fading which require complex equalizers in the receiver to recover the original signal. OFDM overcomes this problem by dividing the wideband channel into a series of narrowband channels which each experience flat fading. Therefore only 1 tap equalizers are required in the receiver, reducing complexity greatly. Despite the many advantages of OFDM it still suffers from some limitations such as sensitivity to carrier frequency offset and a large Peak to Average Power Ratio (PAPR). The large PAPR is due to the superposition of N independent equally spaced subcarriers at the output of the Inverse Fast Fourier Transform (IFFT) in the transmitter. A large PAPR is a problem as it requires increased complexity in the wordlength at the output of the IFFT.

- High PAPR produces out of band radiation affecting adjacent channels and degrading the BER at the receiver.
- One obvious solution is to design the components to operate within large linear regions, however this is impractical as the components will be operating inefficiently and the cost becomes prohibitively high. This is especially apparent in the HPA where much of the cost and ~50% of the size of a transmitter lies.

OBJECTIVE

The objective of this research work is to describe different modulation schemes (Phase-shift keying (PSK), Binary Phase-shift keying (BPSK) and Quadrature amplitude modulation) in OFDM using Rayleigh fading channel and evaluate the performance using Bit Error Rate (BER) and Signal-to-Noise Ratio (SNR). Peak-to-Average Power Ratio (PAPR) is also calculated for these modulation schemes.

IV. PRAPOSED METHDOLOGY

As per the flow diagram (figure 4.1), it is clear that there are three sections namely; transmitter section, channel section and receiver section. In transmitter section, data input is used to insert data which is then modulated in the next section. After that serial to parallel conversion is done. Then IFFT is applied on parallel data stream. Cyclic prefix (CP) is added to the output of IFFT section. After CP insertion, data is again converted from parallel to serial stream. This data is transferred through channel section. At the receiver section the reverse process of transmission section is applied to get the data from the data output.

Figure 4.1: Flow diagram for proposed work

V. SIMULATION RESULTS

Simulations

To simulate the OFDM system a MATLAB test bench is created and simulated the BER performance with following parameters.In this chapter the performance of OFDM system over different Modulation Scheme has been observed. The analysis is based on the study of comparing Bit Error Rate (BER) and Signal to Noise Ratio (SNR) in Rayleigh and Rician channel.The simulation parameters of OFDM system is given in table 5.1.

Table 5.1: Simulation parameters for Rayleigh channel The comparative BER performance with different level for QUADRATURE AMPLITUDE MODULATION and PAPR for different modulation schemes.

S. no	Parameter name	Value
1	No of subcarrier	52
2	FFT size	64
3	Cyclic prefix length	16
4	Pilot and guard	12
5	Channel	Rayleigh
6	Modulation technique	BPSK, 4-PSK, 16-QAM and 64-QAM
7	No. of symbol	10000

BER vs SNR Performance for BPSK Modulation in RAYLEIGH channel

OFDM has been simulated under Rayleigh channel for BPSK Modulation technique.The BER vs SNR graph is plotted. The above simulation result shows the performance analysis of BPSK modulation technique in OFDM. The X axis indicates the SNR value and Y axis is the logarithmic representation of BER.When SNR value is 2 then BER is 0.038.As we increases the value of SNR to 10,we found huge drop in BER ratio i.e 0.0000384.Hence as we increas the SNR then BER reduces and at log scale of $10^{-5.4}$, it becomes 0.

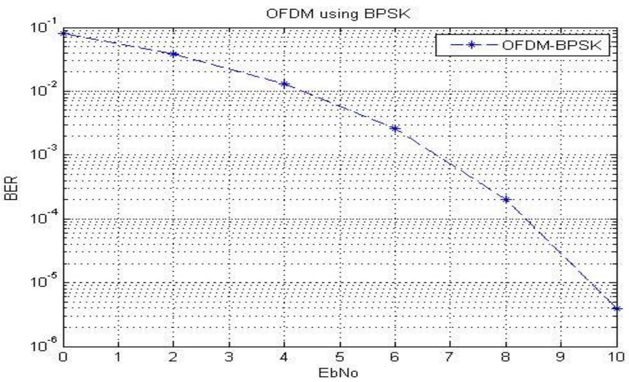

Figure 5.1: BER v/s SNR graph for BPSK modulation in Rayleigh channel

Table 5.2: BER performance for BPSK modulation

Signal-to-Noise Ratio (in dB)	BER
0	0.0804211538461539
2	0.0387692307692308
4	0.0128923076923077
6	0.00259807692307692
8	0.000201923076923077
10	3.84615384615385 e-0.6
12	0

Table 5.2 Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for BPSK modulation Technique .For 0db SNR the BER is 0.0804211538461539 & for 12 db SNR,BER is 0 and it is found that huge drop in BER ratio.

BER vs SNR Performance for 4-PSK Modulation in RAYLEIGH channel

OFDM has been simulated under Rayleigh channel for 4-PSK Modulation technique.The BER vs SNR graph is plotted.

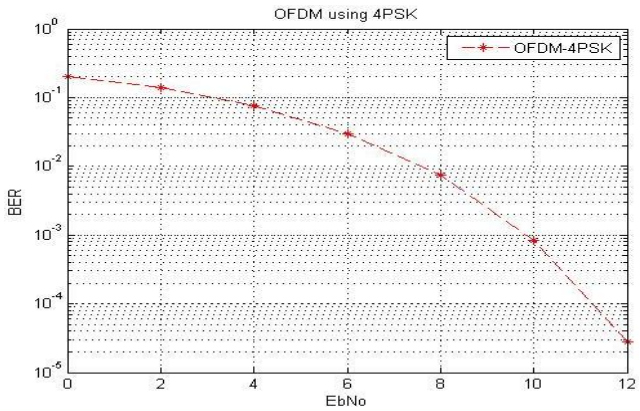

Figure 5.2: BER v/s SNR graph for 4-PSK modulation in Rayleigh channel

The above simulation result shows the performance analysis of 4-PSK modulation technique in OFDM. The X axis indicates the SNR value and Y axis is the logarithmic representation of BER.When SNR value is 2 then BER is 0.01373.As we increases the value of SNR to 10,we found huge drop in BER ratio i.e 0.000892.Hence as we increas the SNR then BER reduces and at log scale of $10^{-5.4}$, it becomes 0.000375.

Table 5.3: BER performance for 4-PSK modulation

Signal-to-Noise Ratio (in dB)	BER
0	0.205343269230769
2	0.137386538461538
4	0.0748903846153846
6	0.0298855769230769
8	0.00735000000000000
10	0.000892307692307692
12	3.75000000000000 e-0.5

Table 5.3 Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for 4-PSK modulation Technique .For 0db SNR the BER is 0.205343269230769& for 12 db SNR,BER is 3.75000000000000 e-0.5 and it is found that huge drop in BER ratio.

5.1.3 BER vs SNR Performance for 16-QAM Modulation in RAYLEIGH channel

OFDM has been simulated under Rayleigh channel for 16-QAM Modulation technique.The BER vs SNR graph is plotted. The above simulation result shows the performance analysis of 16-QAMmodulation technique in OFDM. The X axis indicates the SNR value and Y axis is the logarithmic representation of BER.When SNR value is 2 then BER is 0.2075.As we increases the value of SNR to 10,we found huge drop in BER ratio i.e 0.067876.Hence as we increas the SNR then BER reduces and at log scale of $10^{-5.4}$, it becomes 0.052871.

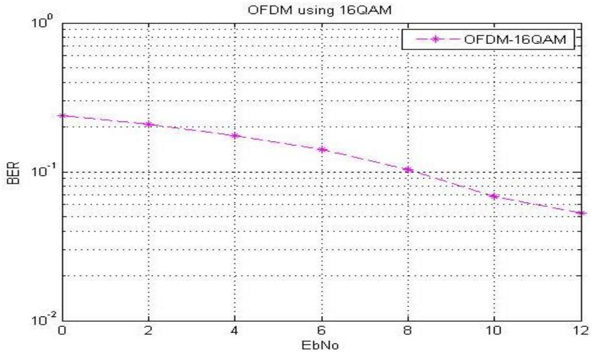

Figure 5.3: BER v/s SNR graph for 16-QAMmodulation in Rayleigh channel

Table 5.4: BER performance for 16-QAM modulation

Signal-to-Noise Ratio (in dB)	BER
0	0.238862500000000
2	0.207579326923077
4	0.175028846153846
6	0.140551923076923
8	0.103404807692308
10	0.0678764423076923
12	0.0528717948717949

Table 5.4 Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for 16-QAM modulation Technique .For 0db SNR the BER is 0.238862500000000& for 12 db SNR,BER is 0.0528717948717949and it is found that huge drop in BER ratio.

5.1.4 BER vs SNR Performance for 64-QAM Modulation in RAYLEIGH channel

OFDM has been simulated under Rayleigh channel for 64-QAM Modulation technique.The BER vs SNR graph is plotted.

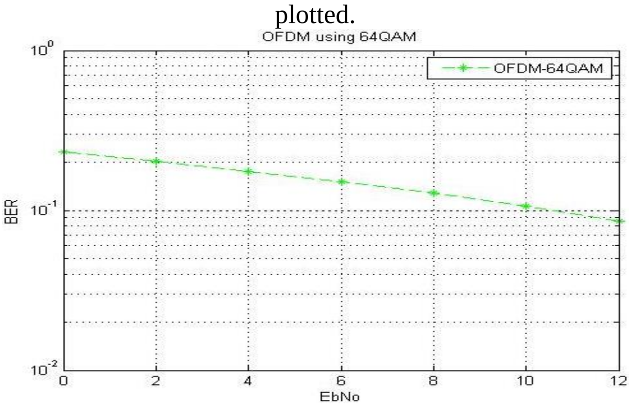

Figure 5.4: BER v/s SNR graph for 64-QAMmodulation in Rayleigh channel

The above simulation result shows the performance analysis of 64-QAMmodulation technique in OFDM. The X axis indicates the SNR value and Y axis is the logarithmic representation of BER.When SNR value is 2 then BER is 0.2024.As we increases the value of SNR to 10,we found huge drop in BER ratio i.e 0.105824.Hence as we increas the SNR then BER reduces and at log scale of $10^{-5.4}$, it becomes 0.0853.

Table 5.5: BER performance for 64-QAM modulation

Signal-to-Noise Ratio (in dB)	BER
0	0.232552884615385
2	0.202449679487179
4	0.175760897435897
6	0.151089102564103
8	0.127568589743590
10	0.105824038461538
12	0.0853692307692308

Table 5.5 Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for 64-QAM modulation Technique .For 0db SNR the BER is 0.232552884615385& for 12 db SNR,BER is 0.0853692307692308and it is found that huge drop in BER ratio in 64 QAM Modulation .

5.1.5 BER vs SNR Performance for Different Modulation schemes inRAYLEIGH channel

OFDM has been simulated under Rayleigh channel for different Modulation techniques. The BER vs SNR graph is plotted.

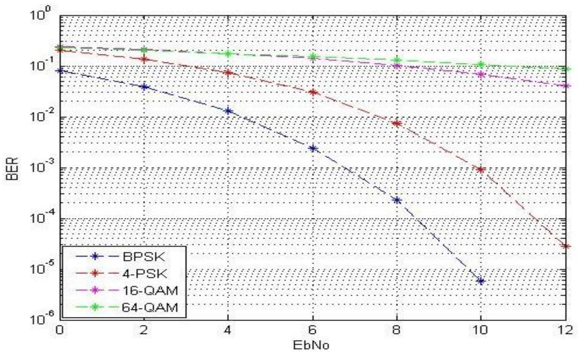

Figure 5.5: Comparative result for different modulation schemes in Rayleigh channel

Figure 5.5 shows the comparative analysis of BPSK,4-PSK,16-QAM and 64-QAM modulation techniques in OFDM.The X axis indicates the SNR value and Yaxis is the logarithmic representation of BER.The BER performance of BPSK is better then other modulation techniques. But at slower data rate; as we increases the data rate, BER performance degrads. If it is 64-QAM, BER performance isless then the 16-QAM,4-PSK and BPSK respectively.

Table 5.6: BER Comparison for different modulation schemes

Signal-to-Noise Ratio (in dB)	Bit Error Rate (BER)			
	BPSK	**4-PSK**	**16-QAM**	**64-Qam**
0	0.0804211538461539	0.205343269230769	0.238862500000000	0.232552884615385
2	0.0387692307692308	0.137386538461538	0.207579326923077	0.202449679487179
4	0.0128923076923077	0.0748903846153846	0.175028846153846	0.175760897435897
6	0.00259807692307692	0.0298855769230769	0.140551923076923	0.151089102564103
8	0.000201923076923077	0.00735000000000000	0.103404807692308	0.127568589743590
10	3.84615384615385 e-0.6	0.000892307692307692	0.0678764423076923	0.105824038461538
12	0	3.75000000000000 e-0.5	0.0528717948717949	0.0853692307692308

Table 5.6 Described about the Signal – to-Noise Ratio in different db and finally get the Bit Error Ratio for different SNR value for different Modulation Technique (BPSK,4PSK,16QAM,64 QAM). It is found that BER performance of BPSK is better then other Modulation Techniques. But at slower data rate; as we increases the data rate, BER performance degrads. If it is 64-QAM, BER performance isless then the 16-QAM,4-PSK and BPSK respectively.

5.1.7 PAPR Performance for Different Modulation schemes inRAYLEIGH channel

In this table 5.9 shows that PAPR decrease from lower modulation technique to higher modulation technique.

Table 5.7: PAPR Comparison different modulation schemes

Modulation Scheme	PAPR
BPSK	9.6158
4-PSK	1.7842
16-QAM	0.7238
64-QAM	0.3403

Table 5.7 shows the PAPR value for different modulation schemes and it is found that the 64-QAM modulation scheme shows lowest PAPR while the BPSK scheme shows the largest PAPR among all systems.

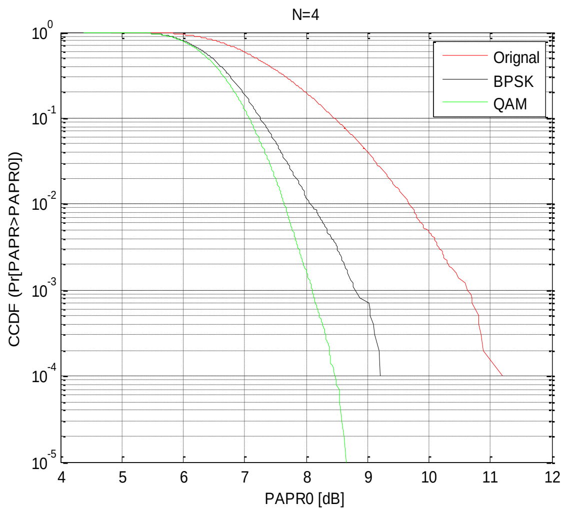

Figure 5.6: PAPR performance of OFDM in Original, BPSK & QAM modulation Technique

VI. CONCLUSION

The work is undertaken in this thesis firstly discusses the OFDM system and fading channel. The implementation of OFDM model is presented with the analysis of the capabilities of OFDM in Rayleigh fading channel. The simulation uses MATLAB and the effect of different modulation schemes has been evaluated over OFDM system.On comparing the variations of the BER for different SNR in the MATLAB simulation, it is observed that the PAPR value for different modulation schemes and it is found that the 64-QAM modulation scheme shows lowest PAPR while the BPSK scheme shows the largest PAPR among all systems.Finally it is concluded that the OFDM system with BPSK scheme is suitable for low capacity short distance applications. While the OFDM with QAM modulation techniques are useful for large capacity and long distance applications which slightly increase the BER. The OFDM promises to be a suitable multiplexing technique for high capacity wireless communication application.

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