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PAPR Reduction Analysis of OFDM signals in DVB-T system using SLM and PTS techniques

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Abstract: DVB-T uses very popular multicarrier modulation system such as OFDM and the OFDM signals in DVB-T has high Peak to Average Power Ratio (PAPR). One way to reduce the high PAPR is by using efficient techniques. In this research, we analyse the PAPR reduction of OFDM signals using SLM and PTS techniques. The input considered for DVB-T system is video signal taken from internet. The simulations of these techniques are carried out using MATLAB.
Keywords: OFDM, DVB-T, SLM, PTS, QAM, PAPR, Techniques

I. INTRODUCTION

Digital terrestrial television (DTT) is also called as Digital Video Broadcasting-Terrestrial (DVB- T) television is currently an efficient communication technology for broadcasting television (TV) signals[1]. The European digital television ETSI EN 300 744, standard is DVB-T, for the terrestrial transmission to fixed, portable, and mobile receivers[2].

The specification of framing structure, channel coding and modulation, for digital terrestrial broadcasting is provided by DVB-T Standard. DVB-T system refers, to the source coding of data, audio signals and video signals, the channel coding and the technique for the transport of the DVB-T signals by means of all type of transmission media. In DVB-T, the OFDM is used to transmit 2k and 8k mode carriers over AWGN, Rician and Rayleigh Channel, the received signal at the receiver is corrupted. The corrupted received signal is manipulated in terms of SNR values (ranging from 0db to 16dB) and modulation techniques (4-QAM, 16-QAM 64-QAM and 128-QAM). OFDM modulation [3] is attractive technique for high data rate transmission, since it can cope with frequency selective fading channel. The Fig.1 gives the DVB-T System Physical Layer block diagram. In DVB-T the most serious problem of OFDM is high Peak to average power ratio (PAPR) which causes degradation of system performance. So reduction of PAPR is very much needed in order to utilize the benefits of OFDM for DVB-T applications. Various PAPR reduction techniques are proposed in literature for OFDM system and in this research we have considered the most widely used techniques such SLM and PTS [4][5].

A. OFDM Model and PAPR

Consider discrete time OFDM model having N subcarriers then the discrete time OFDM signals is

$$x(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X(k) e^{j\frac{2\pi kn}{N}} \tag{1}$$

where $n = \{0, 1, . . ., N-1\}$. We will have $\mathbf{x}$ = IFFT $\{\mathbf{X}\}$, where $\mathbf{X} = [X(0), ..., X(N-1)]^T$, $\mathbf{x} = [x(0), ..., x(N-1)]^T$.
Theoretically, the PAPR of OFDM signal is given as

$$\text{PAPR} = \frac{\max\limits_{0 \le n \le N-1} |x(n)|^2}{E\{|x(n)|^2\}} \tag{2}$$

Where E [·] indicates the expectation operator, $x(n)$ denotes the transmitted OFDM discrete signals which are obtained by applying IFFT(inverse fast Fourier transform) operation on modulated input symbols X(k).

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B. DVB-T System Physical Layer

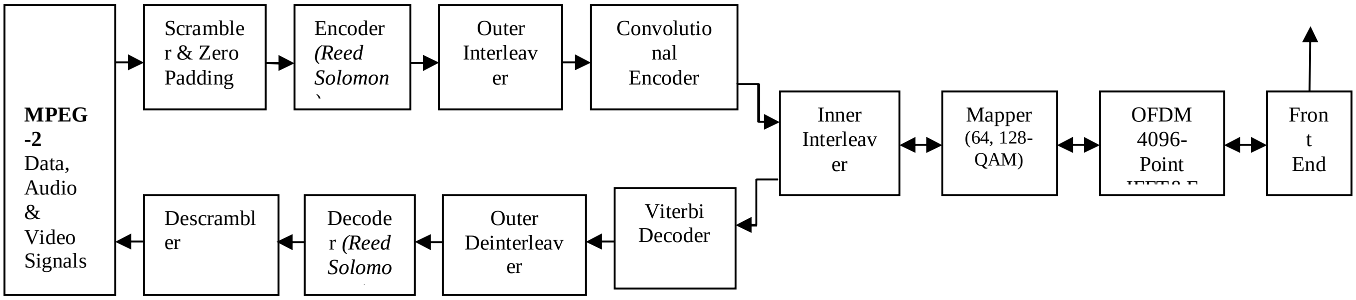

Fig.1 Block diagram of the DVB-T System Physical Layer

II. PROPOSED SLM AND PTS TECHNIQUES

We propose SLM and PTS techniques for PAPR reduction of OFDM signals in DVB-T.

A. Selective mapping (SLM) Technique

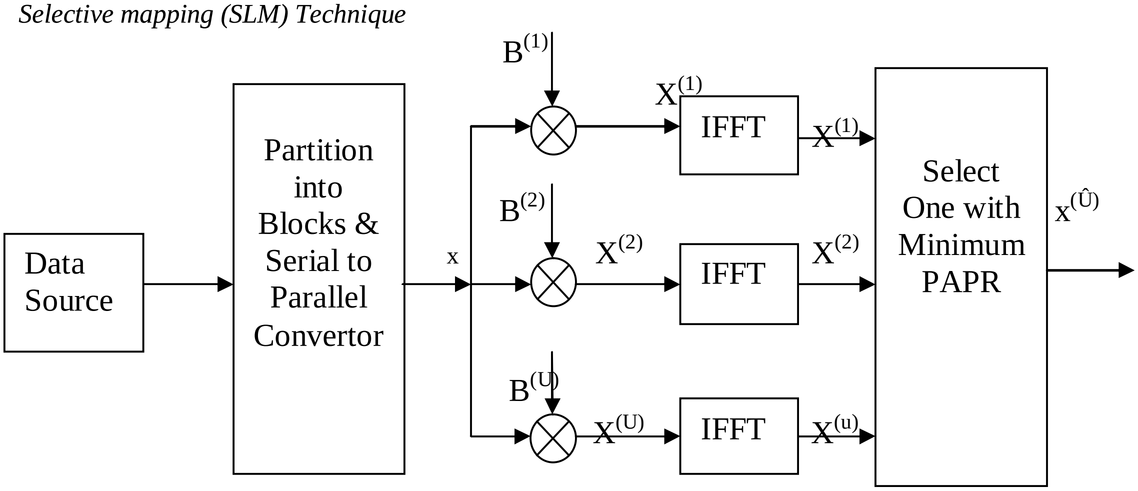

Fig.2 Block diagram of SLM technique

The X(k) is the mapped sub symbol and X is the data block .Where k = 0, 1, 2,..........N − 1. The $B^{(u)}$ indicates the u^{th} phase vector where u = 1, 2, ...U. Fig.2 shows, the block diagram of SLM technique. By using the set {±1, ±j} phase sequences are generated randomly[6]. The $X^{(u)}$ is the u^{th} candidate vector

$$X^{(u)}(k) = X(k)\ B^{(u)}(k) \tag{3}$$

The equation (3) is used to obtain k^{th} element of u^{th} candidate vector.

The U number of alternative OFDM signals is generated using IFFT and it is obtained as

$$x^{(u)}(n) = \frac{1}{\sqrt{N}} \sum_{k=0}^{N-1} X^{(u)}(k)\ e^{j\left(\frac{2\pi nk}{N}\right)} \tag{4}$$

The minimum PAPR value OFDM signal is selected for transmission. The selected OFDM signal is indicated as $x^{(\tilde{u})}(k)$.

In SLM for generation of alternative OFDM symbols the independent phase vectors has to generated $B^{(u)}(k)$ is the k^{th} value of u^{th} phase vector and it is given by

$$B^{(u)}(k) = e^{j\phi^{(u)}(k)} \tag{5}$$

Where $\phi(k)$ or $\phi^{(u)}(k)$ indicates the random phase value. The condition of mutual independence between $b^{(m)}(n)$ and $b^{(l)}(n)$ is

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$$E\left[e^{j\phi}\right] = 0 \quad (6)$$

ϕ must be uniformly distributed in [0, 2π) to satisfy the above condition[7].

B. Partial Transmit Sequence (PTS) Technique

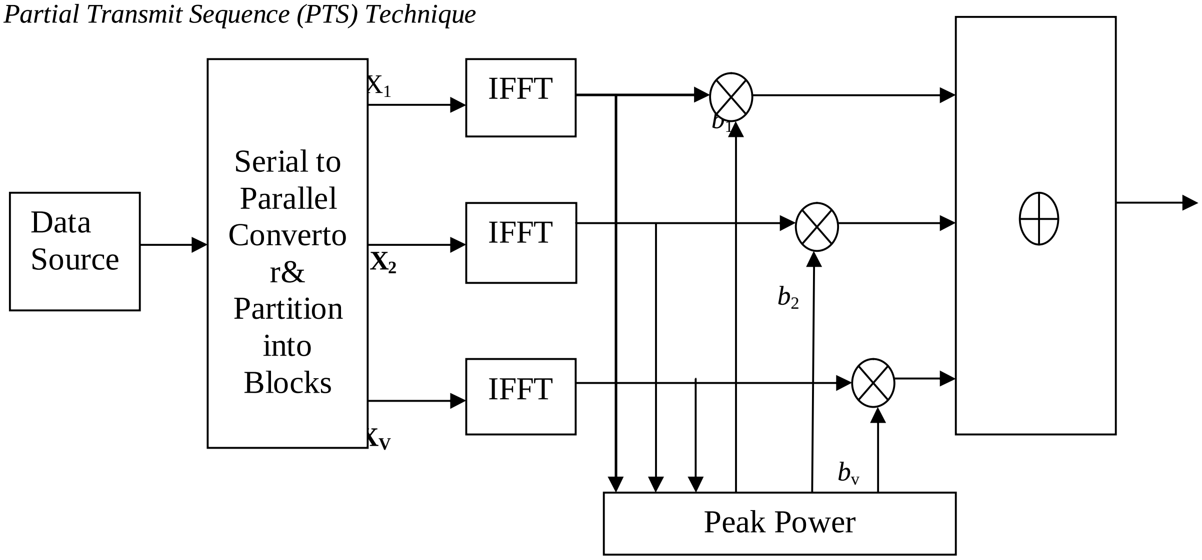

Fig.3 Block diagram of PTS technique

Fig.3 shows, the block diagram of PTS . The data information in frequency domain **X** is separated into *V* non-overlapping sub blocks and the size *N* same for every sub-block vectors [8] [9]. Assuming these sub-blocks has no gap between each other; then the sub-block vector is

$$\widehat{\mathbf{X}} = \sum_{v=1}^{V} b_v \mathbf{X}_v \quad (7)$$

$$b_v = e^{j\varphi_v} \quad (8)$$

$\varphi_v \in [0,2\pi]$ and $v = \{1,2.....V\}$. Where b_v indicates the weighting factor utilized for phase rotation. On applying IFFT on Xv the time domain signal of X_v

$$\hat{\mathbf{x}} = IFFT(\widehat{\mathbf{X}}) = \sum_{v=1}^{V} b_v IFFT(\mathbf{X}_v) = \sum_{v=1}^{V} b_v \cdot \mathbf{x}_v \quad (9)$$

Choose one suitable factor combination **b** = [*b*1, *b*2,…,*bv*] to achieve optimum result. The combination is given as

$$\mathbf{b} = [b_1, b_2, \ldots, b_v] = \arg\min_{(b_1, b_2, \ldots, b_v)}(\max_{1 \le n \le N} |\sum_{v=1}^{V} b_v\ x_v|^2) \quad (10)$$

where arg min (·) is the decision condition that gives, the least value of function. By this way we can have the best **b** in order to optimize the reduction of PAPR performance. The additional cost, is required for extra *V*-1 times IFFTs operation[1] .

III. SIMULATION RESULTS AND DISCUSSIONS

A. Simulation of SLM and PTS Techniques

The simulation of SLM and PTS PAPR reduction techniques, are carried out using MATLAB tool. The input applied to OFDM DVB-T system model is Siblings, a bouncing ball animation_cut.avi video signals taken form internet. The parameters varied in the simulations are given in Table I. simulation is carried out using 64-QAM and 128-QAM.

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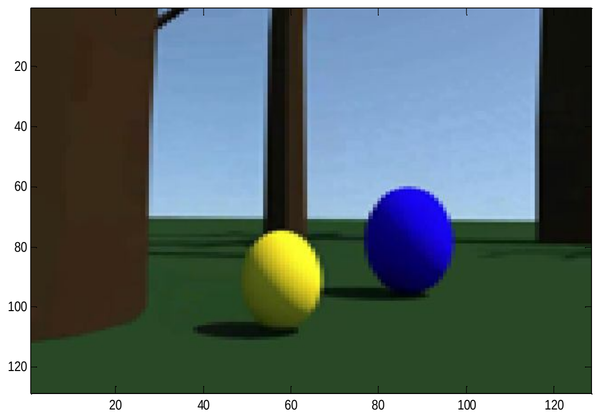

Fig.4 Video frame of sibling, a bouncing ball animation_cut.avi

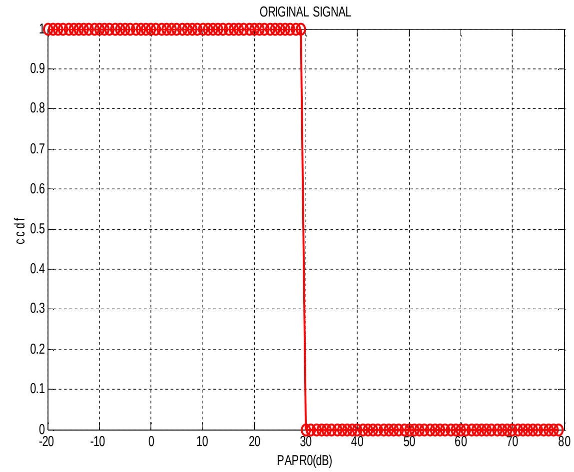

Fig.5 PAPR of original signal for 64-QAM

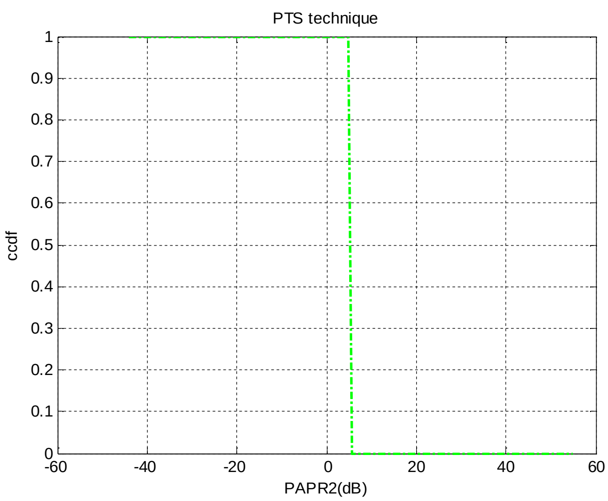

Fig.6 PAPR using PTS technique for 64-QAM

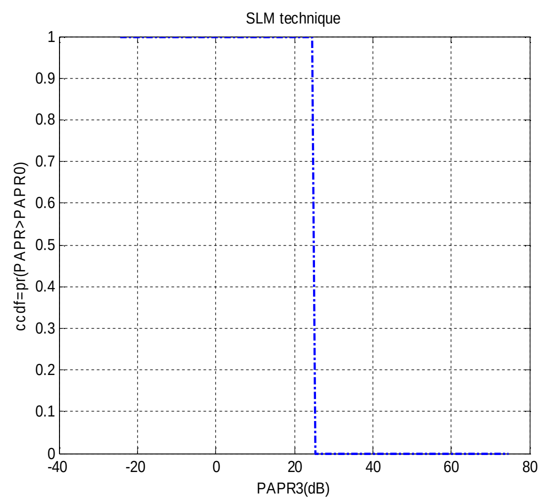

Fig.7 PAPR using SLM technique for 64-QAM

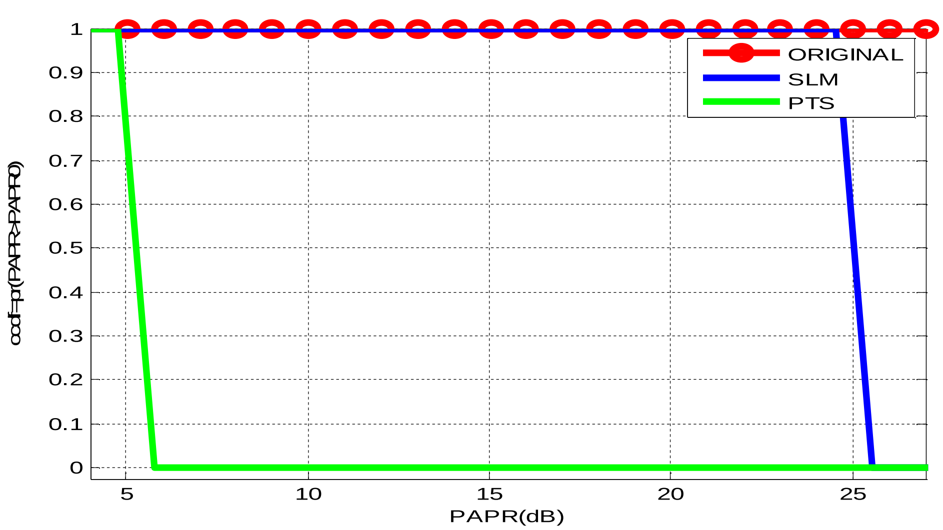

Fig.8 comparison of PAPR using SLM and PTS techniques for 64-QAM with code rate is 3/4

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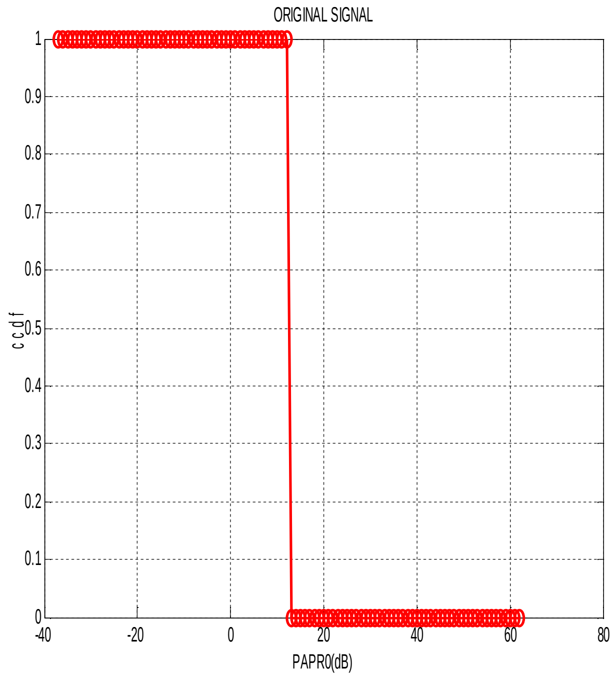

Fig.9 PAPR of original signal for 128-QAM with code rate is 3/4

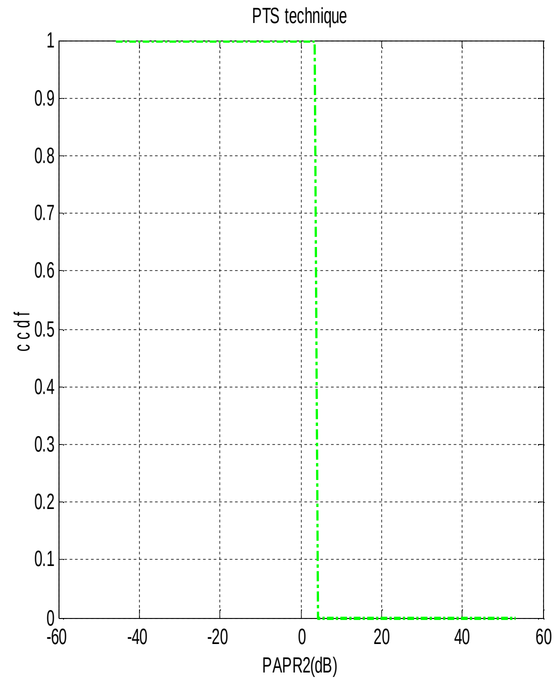

Fig.10 PAPR using PTS for 128-QAM with code rate is 3/4

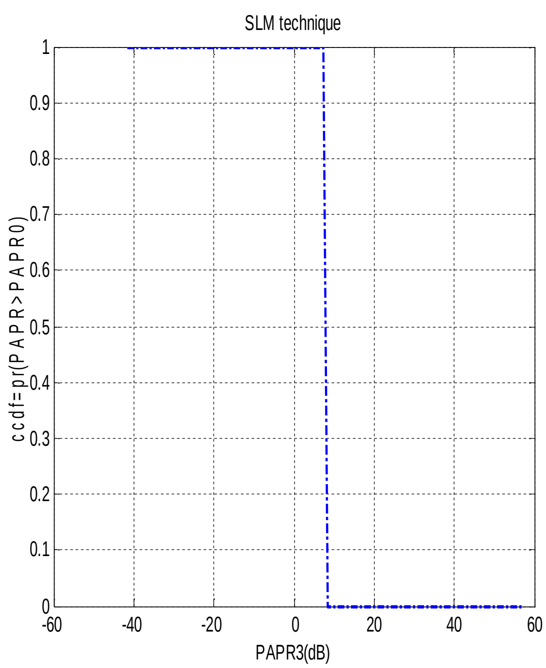

Fig.11 PAPR using SLM techniques for 128-QAM

Simulation Parameters	Value
No of sub carriers (N)	N = 1024
number of OFDM symbol	10 , 50, 100
No of sub blocks (M)	M =2, 4, 8, 16, 32 sub-blocks
Oversampling factor (L)	L=4
Phase factor (P)	P=[1 -1 j -j]
Cyclic Prefix	G = [1/4 ,1/8, 1/16, 1/32]
Code rate	1/2 , 2/3, 3/4
Modulation type	64-QAM and 128-QAM
number of OFDM symbol candidate	C = 4 (for SLM)
number of OFDM symbol candidate	C = 256 (for PTS)

Table I Parameters used in MATLAB Simulation With code rate is 3/4

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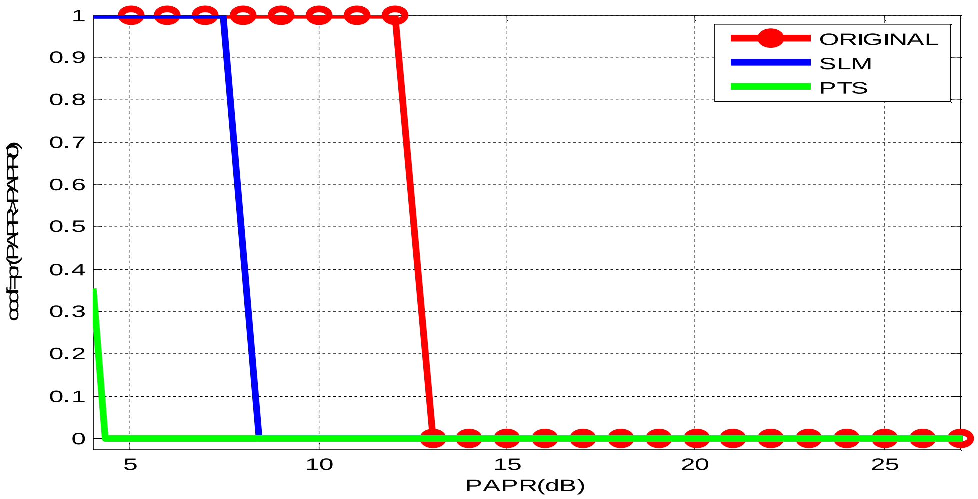

Fig. 12 comparison of PAPR using SLM and PTS techniques for 128 QAM with code rate is 3/4

The simulation results shown in Fig.5 through Fig.12 indicate that PTS technique achieves more PAPR reduction of OFDM signals than that of SLM technique for video signal input with 64-QAM and 128-QAM.

IV. CONCLUSION AND FUTURE WORK

In this research, we have successfully carried out the simulation of SLM and PTS techniques with input: video signal using MATLAB tool. PTS technique provides more PAPR reduction compared to SLM technique. In future work, SLM and PTS techniques are implemented on FPGA.

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