Nonlinearity Improvement in Satellite Communications.

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RESUME

On attend que le 16 etat quadrature AM aure des applications augmentées dans le domaine des communications par satellite les résultats de 16-ary QAM ont montré que les performances des signaux sur deux chaines non-Linéaires sont tres sensibles à la nonlinéairité . On a proposé de produire le signal de 16-ary QAM par sou modulateur de deux quadratures de changement des phases QPSK pour surmonter l'effet de la non-Linéairité de L'amplificateur de puissance de la terre-station .
Le méme avantage est obtenu en utilisant les deux MSK soumodulateurs au lieu de QPSK.
Une expression pour calculer la probabilité d'erreur d'un symbole de "16-ary offset-QAM " a été derivée .

SUMMARY

16 state quadrature AM is expected to find increased applications in the future satellite communications. The results of evaluation 16-ary QAM signal performance over two-link nonlinear channels shows that it is very sensetive to nonlinearities. An approach to over-come the effect of earth station power amplifier nonlinearity on the 16-ary -QAM signal is to generate it by two quadrature phase-shift keying submodulators (QPSK). The same advantage can be taken when the two QPSK submodulators are replaced by two MSK submodultors . In this paper, an expression is derived for the computation of the symbol error probability of 16-ary offset quadrature AM with sinusoidal waveform (16-ary offset - QAM).

1- INTRODUATION :

Satellite communication systems being built today operate under sever bandwidth constraints, also the needed of large capacity communication networks illustrate the importance of studing spectral effecient modulation techniques, as an example the M-ary QAM which required an extremely linear transmitter power stage with minimum conversion (AM/AM & AM/PM) . The main source of nonlinearity over both the up and down links is the TWT, which is the active element in the powr stage at the transponder and which operates in nonlinear part [1].The performance analysis of 16-ary-QAM as given by [2] , shows that signal is very sensetive to nonlinear spectrum of TWT. Fig(1) shows a diagram of two link satellite communication system .

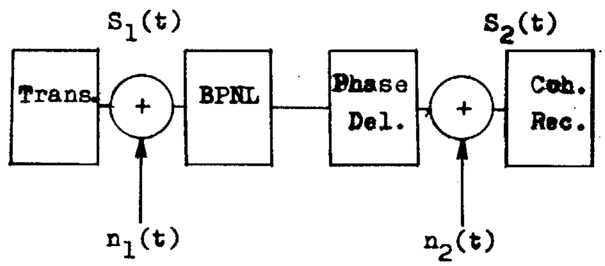

Fig.(1) Diagram of two-link satellite Communication.

Where,

$S_1(t)= U_1 \cos wt - \lambda_1 \sin wt$,

U_1 and λ_1 are indep-random , Variab.

$S_{inp.}(t) = X_1(t) \cos wt - Y_1(t) \sin wt$,

$X_1(t)$ and $y_1(t)$ are quadrature components of up link .

$S_2(t)= X_2(t) \cos wt - Y_2(t) \sin wt$,

for down link ,

K. Feher [5] presents a technique for generation the quadrature amplitude modulation(QAM) signals. Fig.(2) illustrates the block diagram of Nonlinear-16-QAM signal generated by two unfiltered QPSK signals as submodulation (NLA-16-QAM/QPSK).

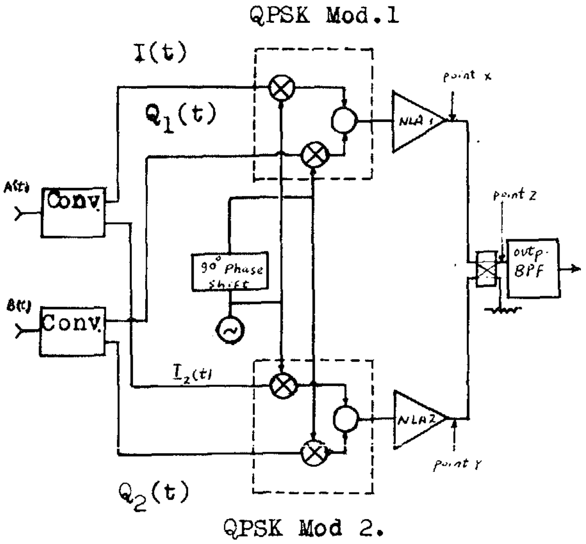

Fig.(2). 16-state NLA QAM/QPSK.

Where :

S_x = G $I_1(t)$ Cos wt

S_y = 2G $I_2(t)$ Cos wt, G is the gain

S_Z = G $Z_1(t)$ Cos wt + $Z_2(t)$Sin wt

The main limitations of NLA-16-QAM/QPSK scheme lies in its complexity and the difficulties of controlling the relative output amplitude and phase of the power amplifier, Fig. (3) shows the dependance of error probability of 16-ary-QAM versus levels of TWT back-off .

In this paper, we introduce another type of modulation that can be used as submodulation in order to obtain better performance .

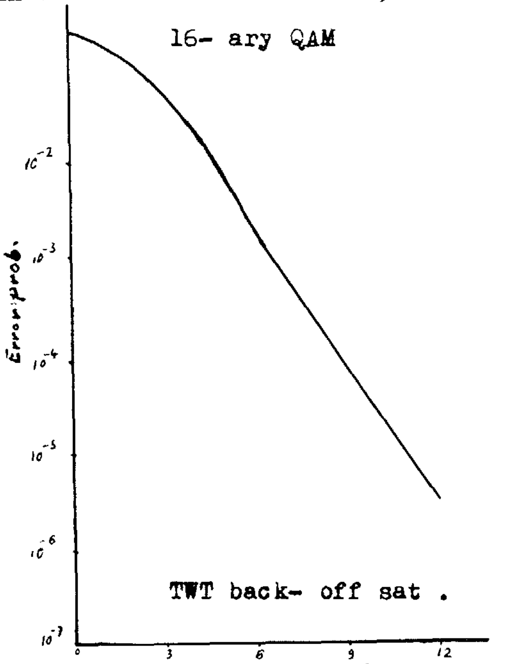

Fig.(3) Error prob. dependance

II- MODIFIED SCHEME FOR GENERATION QAM SIGNAL

It is known that the pulse shaping of MSK gives spectral advantages over QPSK signals [6] . The modified scheme is shown in Fig. (4) .

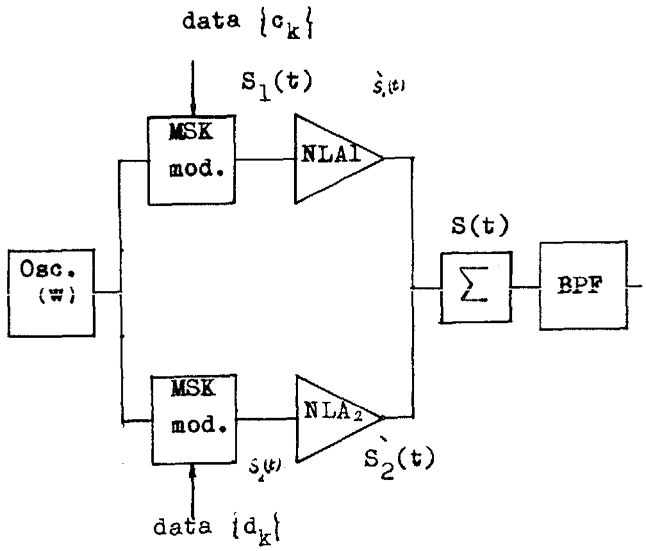

Fig.(4) NLA 16 QAM/MSK modulator

Where ,

$$S(t) = \grave{S}_1(t) + \grave{S}_2(t)$$

$$= G \cos(wt + \Phi_1) + 2G \cos(wt + \Phi_2)$$

Fig. (5), shows signal constellation for the NLA-16-QAM/QPSK and NLA-16-QAM/MSK .In case of using the MSK technique as submodulation signals , the RF filtering problem can be solved by using another simple filter. Moreover, we can say that no abrupt change of the states between I and Q channels in the MSK, which means that the phase transitions are linear and continuous with approximately constant envelope. So, a better performance (p_e versus E_b/ No) of NLA-16-QAM/MSK signal is expected when transmitted through nonregenerative satellite compared with NLA-16 QAM/QPSK signals .

An comporison between NLA-16-QAM/QPSK and NLA-16-QAM/MSK has been done based on the envelope fluctuations and the phase transitions. We can say that abrupt changes of I and Q channels which can be exist in case of NLA-16-QAM/QPSK, will not be found in MSK case . It is noted from Fig.(6) that the effect of back-off values on performance curves is decreased as the degree of back off takes higher values(>15 dB). In this case the transponder power amplifier operates near linear region .

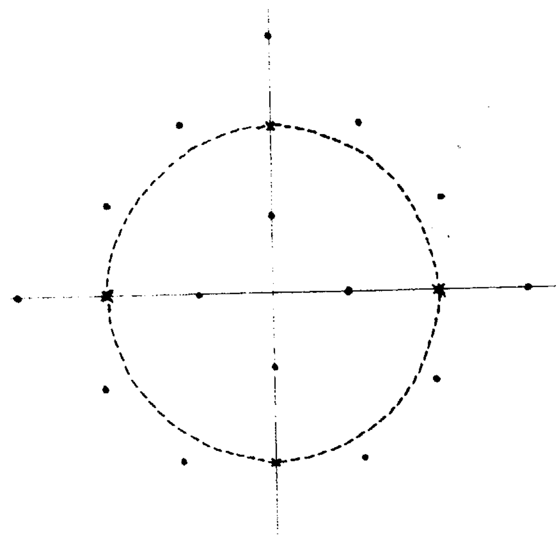

Fig.(5). 16-QAM Constallation

Fg.(6) shows the dependance of error probability as a function of TWT backoff . The comparison between both performances in sattelite nonlinear two link channels with additive gaussion noise is studied by making the suitable computer simulation .

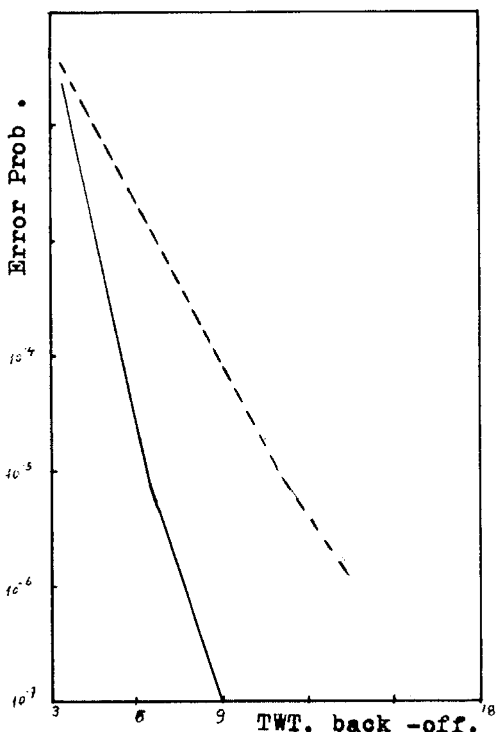

Fig.(6) Error prob. as a function of TWT back-off .
--- NLA 16 QAM/MSK
—— Conventional 16-ary QAM

III- CONCLUSION

Based on the method for generating 16-ary QAM signal (refered as NLA-offset 16-QAM/MSK), an analysis of the performance of the signal transmitted through two link satellite nonlinear channel has been presented . Expressions for symbol error probability have been abtained . The up-and down link AGN and AM/AM and AM/PM conversions of TWT transponder nonlinearity and ISI of the band limited filter are taken into consideration in the given expression. An expression for symbol error probability for the widebased channel is readily evaluated. A study of the effect of back-off of the TWT saturation is included and the system performance is presneted. Compared to conventional 16-QAM [4] or NLA-16-QAM/QPSK an improvements in system performance in order of 3dB back-off or 5dB down-link SNR at error rate of 10^{-4} when up-link SNR is the same (30dB), can be obtained by using the offset NLA-16-QAM/MSK signal. Also optimum peformance is obtained at 12dB back-off compared to 21dB back-off in the case of NLA-16-QAM/QPSK signal .

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