論 文

# Effect of Interference from FM/TV Signal on SCPC/QPSK Signal

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# FM/TV 신호가 SCPC/QPSK 신호에 미치는 간섭의 영향

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ABSTRACT

The effect of interferece from FM/TV signal on SCPC/QPSK signal is investigated by graphic analysis and computer simulation using several kinds of transmission parameters such as the frequency offset spacing between FM/TV and SCPC carriers, the power spectral density of the FM/TV carrier with time rate, etc..

As the baseband type of the FM/TV signal, NTSC color-bar signal is used because it is a kind of the useful test patterns for the analysis of the interference from FM/TV carrier on the other type of transmission carrier. Also the effect of the cochannel interference from tone and SCPC/QPSK interferers as well as FM/TV interferer on SCPC/QPSK carrier is evaluated and compared with each other.

The results of this evaluation and comparison show tat the frequency efficiency can be improved by selection of the time rate low and that for the wide peak-to-peak frequency deviation which is due to the energy dispersal signal of FM/TV carrier, the excess interference falling into the adjacent SCPC carrier would be serious over the occupied band, but the excess interference falling into cochannel SCPC carrier would become less.

要 約

FM/TV 신호가 SCPC/QPSK 신호에 미치는 간섭의 영향을 그래프 해석 기법과 컴퓨터 시뮬레이션에 의해 평가하였다. 평가에 있어서 파라미터로는 FM/TV와 SCPC 반송파간의 주파수 옵셋, 시간율에 따른 FM/TV 반송파의 전력 스펙트럼 밀도 등을 이용하였다. FM/TV 신호의 베이스밴드 신호로는 NTSC 칼

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라-바 신호를 사용하였다. 그 이유로서는 FM/TV 신호가 다른 신호에 미치는 간섭 영향을 평가하는데 있어서 유용한 테스트 패턴의 하나이기 때문이다.

FM/TV 간섭파 이외에도 톤 간섭파와 SCPC/QPSK 간섭파가 SCPC/QPSK 신호에 미치는 동일채널 간섭의 영향을 각각 계산하고 서로를 비교했다.

수치계산한 결과를 비교 검토한 결과, 시간율을 낮게 선택하므로서 주파수 유효이용을 높일 수 있으며 신호의 에너지 확산에 의한 peak-to-peak 주파수 편이가 넓어지게 되면 점유 대역에 걸쳐 SCPC에 미치는 인접채널 간섭이 매우 커지지만 동일채널 간섭은 줄어든다는 것을 알 수 있었다.

## I. INTRODUCTION

Many of INTELSAT systems employ four-fold frequency reuse with adopting the cross-polarization and spot-beam techniques. This frequency reuse may produces an RF interference, i.e., cochannel interference and adjacent channel interference. In satellite communication, FM television signal is a strong source of interference because of the high-density spectral spikes in its power spectrum. Especially this interference is worst when FM/TV carrier shares a given channel with a narrowband carrier such as SPADE or SCPC.

Up to now most of the studies[1]-[3] have been concerned with certain aspects of interference from an FM television signal on an SCPC channel i.e., the relationship among the bit error rate (BER) of the SCPC or the 1/2 FEC encoded SCPC channels and the isolation between the wanted and interfering carriers, the line-rate energy dispersal waveforms over the conventional use of frame rate triangular waveforms, the influence of picture content on the interference, etc.. However most of these studies have been performed by computer simulations or experiments. And the comparisons on the effect of interference from FM/TV carrier and tone or other digital carrier on SCPC/QPSK carrier has not been done yet.

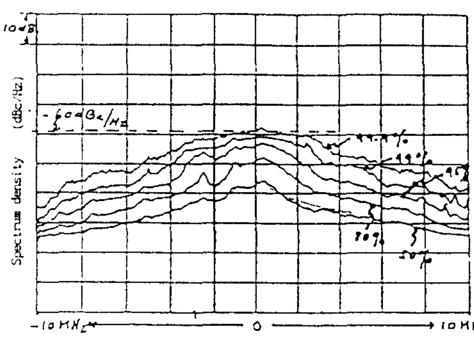
In investigation of the effect of interference from FM/TV signal on the SCPC/QPSK signal, C/I values according to the frequency offsets between two signals have been calculated by use of a practical model of FM/TV signal's power spectrum measured in INTELSAT and a CCIR determination criterion. As the basebnd type of the FM/TV signal, NTSC color-bar signal is used because it is a kind of the useful test patterns for the analysis of the interference from FM/TV carrier on the other type of transmission carrier. Also the effect of the cochannel interference from tone and SCPC/QPSK as well as FM/TV on SCPC/QPSK carrier is evaluated and compared with each other.

## II. GRAPHIC ANALYSIS

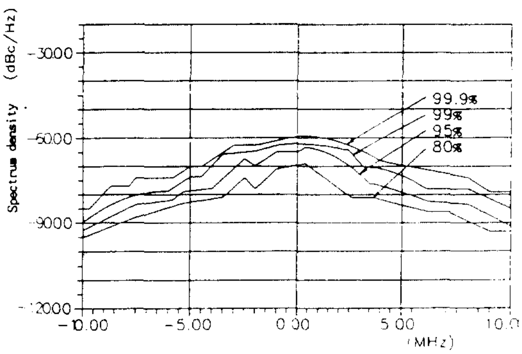
### 1. Spectra of FM/TV

The average spectral density of FM/TV carrier with the time rate measured in INTELSAT is shown in Fig.1(a) and modeled characteristic of that above 80% of time rate in Fig.1(b).

INTELSAT monitoring has indicated that the average spectral density of FM/TV carrier not




(a) Measured characteristic




(b) Modeled characteristic of (a)

Fig. 1. Measured in INTELSAT and modeled average spectral density of FM/TV carrier with the time rate.

exceeded for 99% of time rate was found to be −62 dBc/Hz for frequencies within ±3 MHz from center frequency.

### 2. Interference Analysis

External interfering radio frequency energy(interference) is accommodated by apportining it to the part of total permissible pre-modulation noise. The dB-difference between these carrier to noise ratio's has the nature of an interference accommodation margin M,

$$M = 10 \log \frac{C/N_{internal}}{C/N_{total}} = 10 \log \frac{C/N_{internal}}{C/[N_{internal} + \sum(i)]} \text{ dB} \quad (1)$$

where, $\sum(i)$ denotes all external interference contributions that may have to be accommodated within the margin M.

CCIR Rec. 523 (digital) and 466 (FDM/FM) stipulate that a specific percentage of the total pre-modulation noise is to be allocated to the total aggregate of all internetwork interference contributions $\sum(i)$. If the ratio associated with the percentage allocated to interference is called p, then,

$$p = \frac{\sum(i)}{N_{total}} = \frac{\sum(i)}{N_{internal} + \sum(i)} \quad (2)$$

which, inserted in equation (1), yields,

$$M = -10 \log (1-p) \text{ dB} \quad (3)$$

For the pre-modulation noise percentage, one obtains the margin M.

| | | | | |
|---|---|---|---|---|
| P(%) = | 10 | 15 | 20 | 25 |
| M(dB) = | 0.46 | 0.71 | 0.97 | 1.25 |

In a frequency reuse system, the ratio of total interfering power to that for a single entry as given in CCIR Rec. 523 is 3.33 which has been rounded to 3.5. It will be stipulated that one interfering carrier will be modulated by artificial energy dispersal ; all the other interfering carriers will be assumed to behave like sources of thermal noise. The stipulation is that one interfering carrier (i.e., non-noise-like interferer) may be any one of the assumed 3.5 equivalent single entries ; all the other interfering carriers(i.e., noise-like interferer) may be the assumed 2.5 equivalent single entries.

One method to analyze on the effects of single entry and noise-like aggregate entries, is recorded in document 4/287-E[1], and is given by

$$(C/I)_s = C/N_0 - 10 \log (10^{-X/10} - 10^{-M/10}) + 4 + 10 \log(i_0'/i') + 10 \log b \text{ dB} \quad (4)$$

$$C/I_{NL} = -10 \log[10^{-(C/N_0)/10}(1-10^{-X_{NL}/10})] + 4 + 10 \log(i_0'/i') + 10 \log b \text{ dB} \quad (5)$$

where $10 \log(i_0'/i')$ is the power spectral density of a single noise-like interferer relative to its total carrier power (in dBc/Hz), averaged over the wanted signal's occupied bandwdth b.

The determination of the common solution of equations (4) and (5) is performed by means of a graphic evaluation, as indicated in Fig.2. A horizontal line is drawn intersecting $(C/I)_{single}$, $C/I_{NL}$ and the $C/I_{EDS}$ curves, such that the total degradation (or margin) equals to 0.46 dB, 0.71 dB, 0.97 dB and 1.25 dB, respectively, corresponding to the values of p equal to 10%, 15%, 20% and 25%.

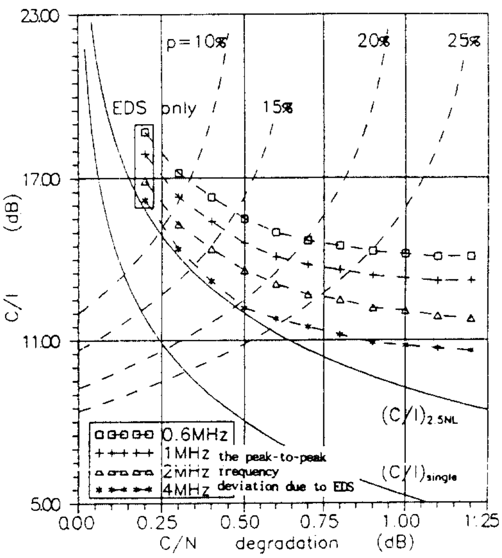
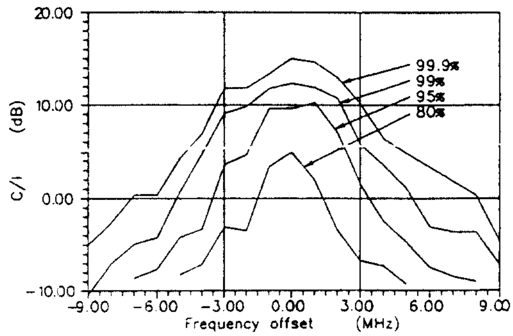



Fig. 2. C/I vs. degradation of C/N ratio.

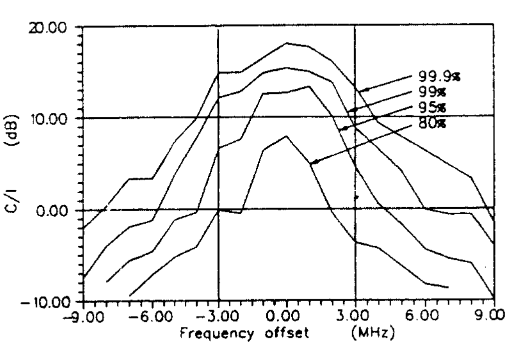



(b) M = 1.0 dB (p = 20 %)

Fig. 3. C/I values vs. the frequency offset and the time rate.

### 3. Analysis Results

The effect of a single noise-like interferer on SCPC/QPSK carrier has been calculated by utilization of an approximate average spectral density of FM/TV carrier (as shown in Fig.1(b) and a graphic method (as shown in Fig.2). The numerical results for 0.46 dB which is rounded to 0.5 dB(p = 10%) and 0.97 dB which is rounded to 1.0 dB (p = 20%) of C/N degradation margin are shown in Fig.3(a) and (b), respectively.




(a) M = 0.5 dB (p = 10%)

## Ⅲ. SIMULATION

### 1. Block Diagram

The simulations are performed for the analysis on the effect of interference from a color-bar TV signal on a 2 Mb/s SCPC/QPSK channel. A schematic block diagram of the simulation is given in Fig.4. A routine generating two consecutive NTSC lines produces an array of 16,384 samples for the 128 μs observation window and it is connected to a frequency modulation routine after having been pre-emphasized according to a filter given in CCIR Rec. 405-1[5]. The center frequency of TV signal is then shifted by the wanted frequency offset and filtered by the QPSK receive filter. The current coditional probabilities of error relative to the values of the interferer are computed for each sample(i.e., 16,384 samples) and averaged. This approach is the same as that consisting of a QPSK signal generation followed by an ideal channel filtering with interference addition between transmit and receive sections. The advantage lies in averaging the probabilities of bit error over all the possible data stream delays (relative to the TV line start time), thus improving the stability of the results within minimum computing time.

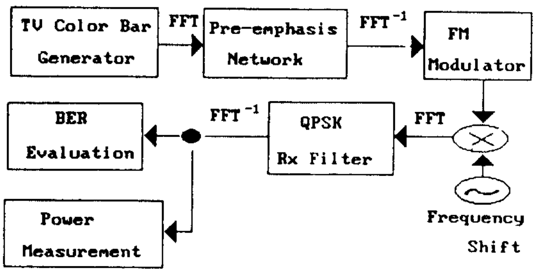
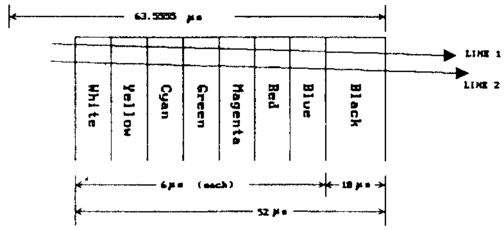



Fig. 4. Block diagram of the simulation process.

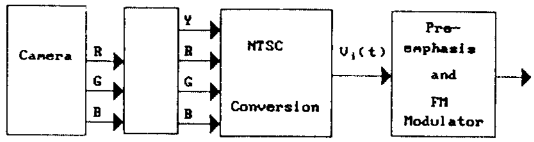
## 2. Simulation of the NTSC Transmission Format

In simulation, a fixed sampling rate of 4,096 times the horizontal line scan rate is used. Exactly two scan lines are simulated, giving a data block size of 8,192 points. The NTSC scan line has a duration of $T_H = 286/4.5 \times 10^6 = 63.555\ \mu s$ for a horizontal line scan rate of 15.734 kHz. Each scan line in the simulation is presented by 4,096 discrete samples for a sampling frequency of $f_s = 4,096/T_H = 64.447 \times 10^6$ samples/s. All frequencies in the simulation are scaled, and the 64 MHz sampling rate is high enough to accurately represent the output signal of FM modulation that occupies a channel bandwidth of approximately 24 MHz. The extension of this model to address adjacent channel interference effects requires a doubling of $f_s$ to 128 MHz and a doubling of the block size to 16,384 samples[16].

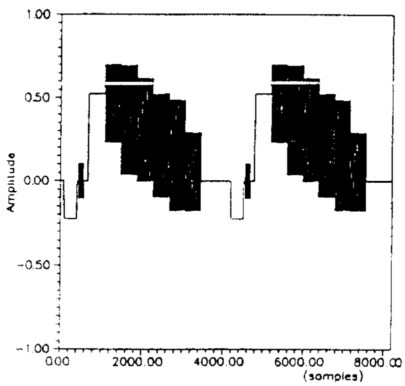
The generation of the simulated time compressed NTSC color-bar pattern is shown in Fig.5(a). With ideal NTSC conversion, the simulation can be dealt with only the compressed NTSC waveform that is low-pass filtered and applied to the FM modulator, as shown in Fig.5(b). The simulation is dealt with a highly oversampled version of the voltage waveform $V_i(t)$, as shown in Fig.5(c). Table 1 shows the apportionment of samples in the simulation to the time intervals in the various segments of the time-compressed NTSC scan line.




(a) Scanning of color bar pattern




(b) Simulated modulating waveform $V_i(t)$




(c) Sampled version of $V_i(t)$ for two scan lines (8, 192 samples)

Fig. 5. Method of simulating NTSC transmission of a color bar pattern.

Table 1. Segments of scan line out of NTSC converter.

| Segment | Duration (μs) | Integer number of samples |
|---|---|---|
| Front porch | 1.5 | 96 |
| Sync. pulse | 4.7 | 304 |
| Back porch | 5.35 | 349 |
| Color bars | 53.0 | 3347 |
| Total | 63.55 | 4096 |

### 3. Pre-emphasis

A pre-emphasis characteristic given in CCIR Rec. 405-1 is defined as[5]

Relative deviation (dB)

$$= 10 \log [(1+zf^2)/(1+yf^2)] - x \qquad (6)$$

where x is the attenuation (dB) at a low frequency (<0.01 MHz), y and z are constants which determine the shape of the pre-emphasis characteristic, and f is the frequency (MHz).

The preferred values of y and z for the 525-, 625-, and 819-line systems are shown in Table 2. The shapes of the characteristics are shown in Fig.6. The NTSC color-bar pattern pre-emphasized by the characteristic of A is shwn in Fig.7.

Table 2. Values of coefficients of pre-emphasis characteristics.

| Number of lines | 525 | 625 | 819 |
|---|---|---|---|
| x | 10.0 | 11.0 | 7.0 |
| y | 1.306 | 0.4083 | 0.1021 |
| z | 28.58 | 10.21 | 2.552 |
| Cross-over freq. (MHz) | 0.7616 | 1.512 | 1.402 |
| Deviations at low frequencies (MHz) | 2.530 | 2.255 | 3.573 |

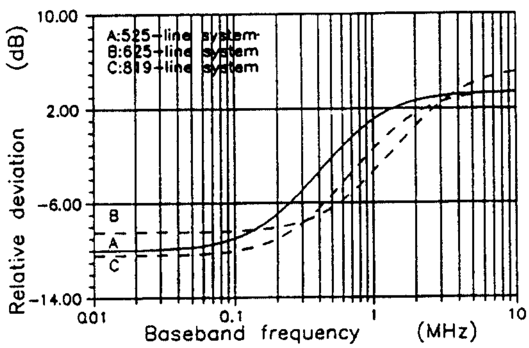



Fig. 6. Pre-emphasis characteristic for television on 525-, 625, and 819-line systems.

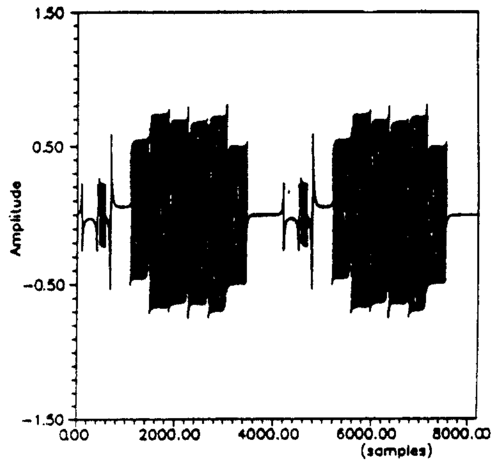


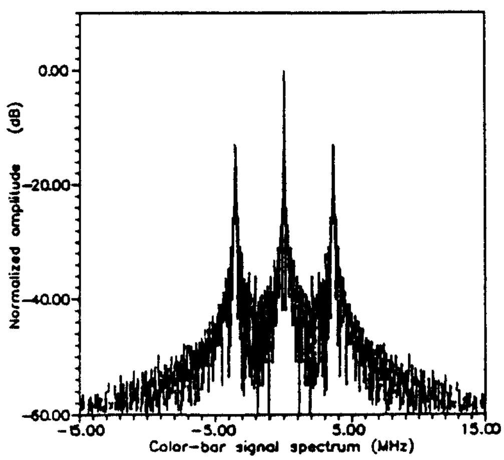

Fig. 7. NTSC color-bar pattern after pre-emphasis.

### 4. FM Transmitter

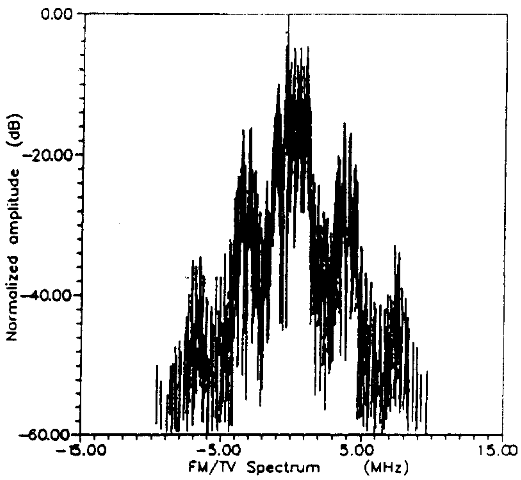
The FM transmitter subroutine accepts the input modulating waveform $V_i'(k\triangle)$ and generates a simulated frequency modulated signal $S_T(k\triangle)$, as follows[6]

$$S_T(k\triangle) = \exp\{ j2\pi\beta \sum_{m=1}^{k} V_i'(m\triangle)\} \qquad (7)$$

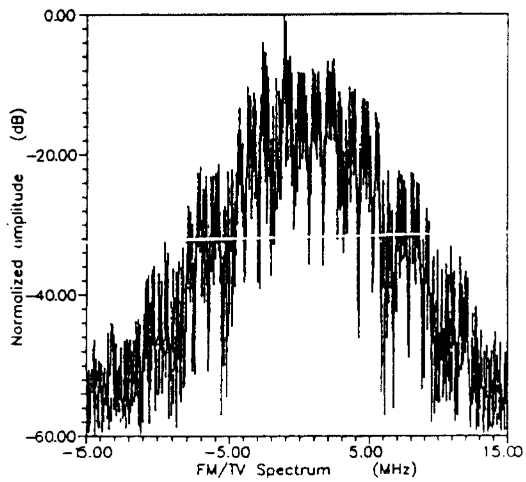
where $\beta(=\triangle F_{pk}/f_s)$ is peak frequency deviation divided by the sampling frequency, $f_s$ and $V_i'(m\triangle)$ is the test pattern of $V_i(m\triangle)$ after filtering, pre-emphasis and amplitude normalization respectively.




(a) Color-bar pattern




(b) $\Delta F_{pk} = 7.8$ MHz




(c) $\Delta F_{pk} = 17$ MHz

Fig. 8. Simulated power spectrum density of color bar and FM modulated signals.

The simulation is done to obtain a series of power spectrum density for NTSC transmission for various values of peak frequency deviation $\triangle F_{pk}$. These results are shown in Fig.8. Fig.8(a) shows the baseband spectrum for color-bar modulation for NTSC. In Fig. 8(b) and (c), spectra at the output of the simulated FM transmitter are shown for two values of $\triangle F_{pk}$. As a reference, for the 24 MHz and 36 MHz satellite channel bandwidth, Carson's rule deviation are 7.8 MHz and 17 MHz, respectively.

### 5. Simulation Results

The simulation is based on an initial C/N value which is corresponded to a BER of 1 in $10^6$ in the absence of interference. The performance of 2.048 Mb/s QPSK modem is simulated and compared to the error performance of QPSK signal evaluated theoretically in Fig.9.

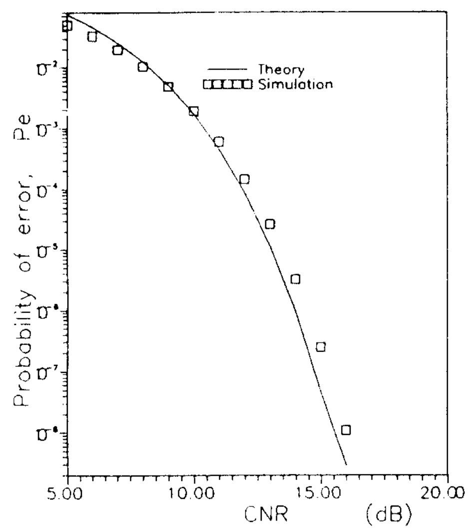



Fig. 9. QPSK modem performance for 2.048 Mb/s.

From simulation results, we can see that the C/N required for BER of 1 in $10^6$ is about 14.74 dB. The goal of simulation is to determine the values of C/I corresponding to the degradation in C/N of 0.5 dB and 1.0 dB degradation points. When $\triangle F_{pk}$ is 7.8 MHz and 17 MHz each necessary C/I and FM/TV power which falls within a Nyquist filter of 2.048 MHz bandwidth are given in Table 3.

Using the results in Table 3, the effect of interference of color-bar signal according to $\triangle F_{pk}$ is shown in Fig.10.

In Fig.11, the modeled spectra of FM/TV signal measured in INTELSAT are compared to those of

Table 3. Necessary C/I values to limit degradation in C/N to 0.5 dB and 1.0 dB.

| Frequency offset (MHz) | $P_B/P_{TV}$ (dB) | | Necessary C/I(dB) | | | |
|---|---|---|---|---|---|---|
| | | | 0.5 dB C/N Deg. | | 1.0 dB C/N Deg. | |
| | $\Delta F_{PK}$ = 7.8MHz | 17MHz | 7.8MHz | 17MHz | 7.8MHz | 17MHz |
| 7 | | −22.5 | | −1.9 | | −4.5 |
| 6 | | −17.1 | | 4.7 | | 2.2 |
| 5 | −20.2 | −12.4 | 0.2 | 8.2 | −2.2 | 5.6 |
| 4 | −15.6 | −10.8 | 3.8 | 9.2 | 0.9 | 6.3 |
| 3 | −16.9 | −7.8 | 2.5 | 13.2 | −0.1 | 10.5 |
| 2 | −10.7 | −6.2 | 11.0 | 14.2 | 8.9 | 10.5 |
| 1 | −3.4 | −6.6 | 16.4 | 13.2 | 13.1 | 10.2 |
| 0 | −1.0 | −5.4 | 17.9 | 14.0 | 14.4 | 11.0 |
| −1 | −3.2 | −4.4 | 16.2 | 15.6 | 13.3 | 12.7 |
| −2 | −11.8 | −5.3 | 10.9 | 14.6 | 9.1 | 11.7 |
| −3 | −15.5 | −8.0 | 3.9 | 13.0 | 0.9 | 10.3 |
| −4 | −16.9 | −12.2 | 2.5 | 8.1 | −0.1 | 5.5 |
| −5 | | −18.1 | | 3.7 | | 0.9 |
| −6 | | −22.1 | | −2.0 | | −4.6 |
| −7 | | −22.5 | | −2.2 | | −5.2 |

simulated FM/TV color-bar signal in order to discuss the analysis and the simulation results. Also, the comparison of the necessary C/I values between evaluated and simulated ones for M = 1.0 dB(i.e., C/N degradation is 1.0 dB) is shown in Fig.12.

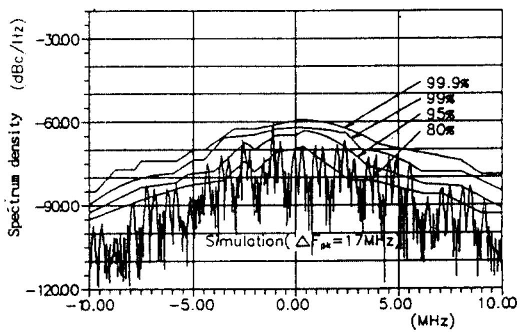



Fig. 11. Comparison of spectra between modeled FM/TV and simulated color-bar signals.

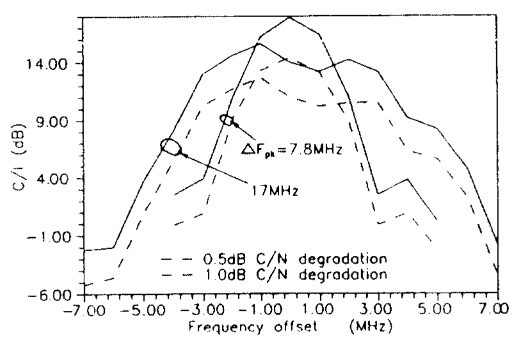



Fig. 10. Necessary C/I values vs. $\Delta F_{pk}$.

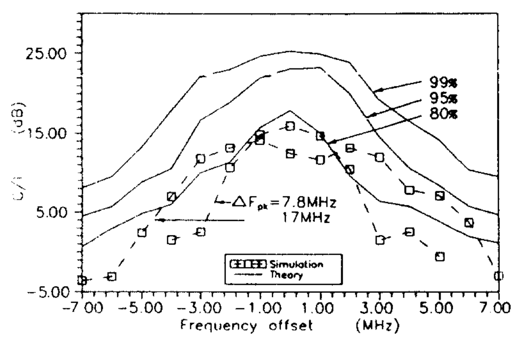



Fig. 12. Comparison of graphic analysis and simulation for M = 1.0 dB.

## Ⅳ. COMPARISON OF THE EFFECTS OF FM/TV, TONE AND SCPC/QPSK INTERFERERS

In a frequency reuse communication system, cochannel interference (CCI) is one of the major sources of the performance degradation[7]. For discusson on the effect of CCI on SCPC/QPSK carrier, FM/TV, tone and SCPC/QPSK carriers are introduced as interferers. Previously, much has been studied on the effect of tone interference on the QPSK signal[8], and the bit error probability for QPSK signal is given as[9],

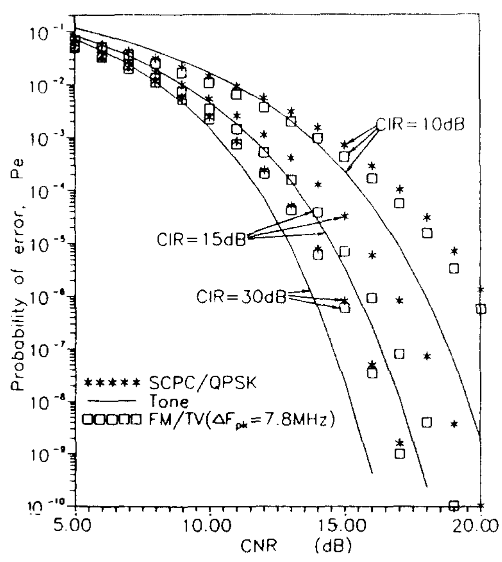
$$Pe_{(QPSK)} = \mathrm{erfc}\{\sqrt{\rho}\ \sin(\pi/4)\} + 2/\sqrt{\pi}\ \exp\{-\rho \sin^2(\pi/4)\} \cdot \sum_{k=1}^{\infty} H_{2k-1}(\sqrt{\rho}\ \sin(\pi/4))\ (\rho/\alpha)^k \frac{1}{2^{2k}(k!)^2} \quad (8)$$

where, $H_n(x)$ : nth-order Hermite polynomial,

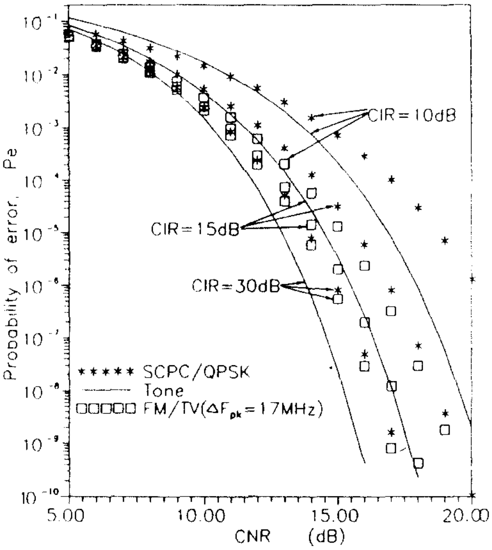
$\rho$ : the carrier-to-noise power ratio(CNR),

$\alpha$ : the carrier-to-interference power ratio(CIR).

In this paper, the effects of FM/TV for $\triangle F_{pk}$ = 7.8 MHz and 17 MHz, SCPC/QPSK cochannel interference on SCPC/QPSK carrier has been investigated by computer simulation methods given in Ref.(7) when the center frequency of an interfering channel is introduced to the carrier frequency of the main channel, and compared to that of tone interference as shown in Fig.13(a) and (b).




(a) $\Delta F_{pk}$ = 7.8 MHz




(b) $\Delta F_{pk}$ = 17 MHz

Fig. 13. Comparison of the effects of FM/TV, tone and SCPC/QPSK interferers on SCPC/QPSK carrier.

## Ⅴ. NUMERICAL RESULTS

Fig.3(a) and (b) show the C/I values according to frequency offset for M = 0.5 dB and 1.0 dB of C/N degradation margin introduced by the graphic analysis method. It is apparent from Fig.3(a) (i.e., M = 0.5 dB) that if C/I criterion in the case of the interference from FM/TV on SCPC/QPSK carrier is 10 dB, the frequency offsets are requried to be about ± 4MHz, ± 3.5MHz and ± 2MHz, respectively, of the time rates of FM/TV spectrum equal to 99.9%, 99%, and 95%. Also from Fig.3(b) (i.e., M = 1.0 dB), the frequency offsets are required to be about ± 3.5MHz and ± 2MHz, respectively, when time rates equal to 99.9% and 99%.

Fig.10 shows the C/I values that give degradations of 0.5 dB and 1.0 dB in terms of C/N value required for BER$=10^{-6}$ in each case of $\triangle F_{pk}=7.8$ MHz and $\triangle F_{pk}=17$ MHz, respectively, by simulating the effect of NTSC color-bar FM/TV interferer on SCPC/QPSK carrier. In Fig.10, it is found that for $\triangle F_{pk}=7.8$ MHz, when the frequency offset is 0MHz, the C/I values have maximum values of 17.9 dB and 14.4 dB, respectively, with C/N degradations of 0.5 dB and 1.0 dB, and the effect of interference in these points is worst. And if the frequency offsets are greater than +3 MHz or smaller than −3 MHz, the effect of interference is reduced remarkably However, for $\triangle F_{pk}=17$ MHz, when the frequency offset is −1 MHz, the C/I values have maximum values of 15.6 dB and 12.7 dB, respectively, with the C/N degradations of 0.5 dB and 1.0 dB. The reason is that the peak of color-bar FM/TV signal spectrum appears at the frequency offset of −1 MHz as shown in Fig.8(c). In this case, if the frequency offsets are greater than +7 MHz or smaller than −6 MHz, the effect of interference becomes lesser. In other words, the effect of color-bar FM/TV interferer on SCPC/QPSK carrier occurres over a wider range of the frequency offset according to the increase of peak frequency deviation, $\triangle F_{pk}$.

Fig.12 shows the C/I values versus frequency offset for M$=1.0$ dB (i.e., C/N degradation equals to 1.0 dB) in order to compare the results of graphic analysis with those of simulation on the effects from FM/TV interference into SCPC/QPSK carrier. From Fig.12, we note that in the case of graphic analysis for time rate of FM/TV spectra greater than 95%, the C/I values are higher than those of simulation. On the other, compared to the simulation result, the C/I values obtained by graphic analysis for 80% of time rate are lower in frequency offset range from about − 5 MHz to − 1 MHz and from about 1 MHz to 6 MHz. The reason is that in these points, the modeled components of spectrum are lower than the simulated those as shown in Fig.11.

Fig.13 (a) and (b) show the BER performance of SCPC/QPSK carrier due to the effects from FM/TV cochannel interference of $\triangle F_{pk}=7.8$ MHz and $\triangle F_{pk}=17$ MHz, respectively, in comparison with the effects from tone and SCPC/QPSK interferers. In Fig.13 (a) (i.e., $\triangle F_{pk}=7.8$ MHz), it is found that FM/TV interference is more serious than tone interference, but less than SCPC/QPSK interference. As an example, when CIR is 15 dB, CNR's need for BER$=10^{-6}$ are 16 dB, 16.5 dB and 17.5 dB, respectively, in each case of FM/TV, tone and SCPC/QPSK interferer, However, from Fig.13 (b) (i.e., $\triangle F_{pk}=17$ MHz), it is found that the interference from FM/TV interferer is less serious than tone and SCPC/QPSK interferers when CIR are 10 dB and 15 dB, but more serious than tone interferer when CIR is 30 dB. As an example, in the FM/TV interference case, the CNR needed to obtain BER of $10^{-6}$ is 15.5 dB. Also, from Fig.13 (a) and (b), we know that when CIR is 10 dB, FM/TV interference is more serious than tone interference in Fig.13 (a), but less serious in Fig.13(b). The reason is that as described above in Fig.10, when he frequency offset is 0 MHz (i.e., cochannel interference effect), C/I value for $\triangle F_{pk}=7.8$MHz is larger than that for $\triangle F_{pk}=7$ MHz, and that power spectrum density is cocentrated at 0 MHz of frequency, but −1 MHz of frequency as shown in Fig 8 (b) and (c), respectively.

## Ⅵ. CONCLUSIONS

In this paper, the trade-off relationship between frequency offsets and time rates of FM/TV spectrum based on the measurement in INTELSAT is found. For a fixed C/I criterion, if the time rate is chosen to be smaller, the frequency offset becomes lower, i.e., the frequency efficiency improves. For verification of the graphic analysis, computer simulations on the effects of interference from NTSC color-bar FM/TV carrier on SCPC/QPSK carrier have been carried out and comparison with those obtained in graphic analysis is done. As the results, the C/I determination technique based on power spectrum analysis is confirmed to be valid and the frequency efficiency can be improved by selecting the time rate low. Also the effect of interference from tone, SCPC/QPSK and FM/TV carriers on SCPC/QPSK carrier has been evaluated respectively and compared each other. It is known that for the wide peak-to-peak deviation which is due to the energy dispersal signal of FM/TV carrier, the excess interference falling into the adjacent SCPC carriers would be serious over the occupied band, but the excess interference falling into cochannel SCPC carriers would become less.

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## REFERENCES

1. J.Dutronc, J.M.Freixe, D.Prouse and R.Cooke, "FM/TV interference into rate 1/2 FEC encoded SCPC/QPSK," Int. J. Satellite Comm., vol.4, pp.111-126, Sep. 1986.
2. S.E.Yam, "New TV energy dispersal techniques for interference reduction," COMSAT Tech. Rev., vol.10, no.1, pp.103-150, Spring 1980.
3. J.P.Albuquerque, R.Mukunda, and O.Shimbo, "On the choice of an efficient TV energy dispersal waveform for interference reduction," IEEE Trans. Comm., vol.COM-34, no.9, pp.965-969, Sep. 1986.
4. "Revision of interference criteria for the protection of SCPC/CFM and encoded QPSK transmissions," CCIR Study Group, Doc. 4/287-E, May 1989.
5. "Pre-emphasis characteristics for frequency modulation radio-relay systems for television," CCIR Rec. 405-1, 1990.
6. L.C.Palmer and A.Shenoy, "Simulation of TV transmission over the communications satellite channel," IEEE Trans. Comm., vol.COM-34, no.2, pp.188-199, Feb. 1986.
7. J.S.Seo, "Superposed quadrature modulation (SQAM)," Ph. D. Dissertation, Univ. of Ottawa, Canada, 1984.
8. A.S.Rosenbaum, "PSK error performance with Gaussian noise and interference," B.S.T.J., vol.48, no.2, pp.413-442, Feb. 1969.
9. B.O.Kong, "A study on the error performance of digital modulation systems in the composite environments of fading, interference and noise," Ph. D. Dissertation, Hankuk Aviation Univ., 1991.

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