CCITT SGXV
Working Party XV/1
Specialist Group on Coding for Visual Telephony

Document # 62
January, 1986

SOURCE : NTT, KDD, NEC and FUJITSU

TITLE : VQ-BASED CODING ALGORITHM

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1. Introduction

This document describes a VQ-based coding algorithm within the frame work as described in the companion document #60. Therefore, the algorithm described in this document is applied to the motion compensated interframe prediction error signals. Motion-compensated interframe prediction errors are segmented into blocks. After significant/insignificant detection of each block, only significant blocks are coded by a VQ-based coding algolithm.

A component VQ coder module which has a coarse component coder (C-coder) and a fine component coder (F-coder) is described first, and a total coding system consisting of several VQ coder modules is shown. In a total coding system, adaptive spatial subsampling technique is introduced on a block by block basis, providing the system with flexibility against the variation of input signals. The control algorithm is also described in the contribution. An example of simulation results is also presented in Annex.

2. A Component VQ Coder Module (VQ Module)

Fig. 1 shows the general structure of a component VQ coder module. The module can be separated into two parts, namely a quantizer part and the variable word length coder part.

The quantizer consists of a C-coder and an F-coder. The C-coder carries out a vector quantization on the signal blocks of the size of 4 x 4 pels. The tree search method is used to obtain the best matched vector. In the F-coder, the input signal is compared with the corresponding vector quantized output. When the difference exceeds the threshold, that difference is further scalar quantized.

In the variable word length coder block, vector index and scalar quantized difference signal are coded using Huffman coding method. The address information of scalar quantized pels is run length coded.

3. VQ-Based Coding System

The total coding system can be realized by connecting VQ modules mentioned above in a hierarchical manner. Spatial subsampling and the interpolation techniques are adopted on a block by block basis of the size of 8 x 8 pels depending on the local characteristics of the input signals. In the subsampling mode, 8 x 8 pel block is degenerated into one or more 4 x 4 pel blocks to be coded by a VQ module. Details on subsampling and relevant processing are left for further study.

Fig. 2 shows one example of the system configuration. In this system the judgement is done whether the normal vector quantization or subsampling vector quantization is applied to the input signal. When the normal coding is selected both switches are connected to n, and the other case to s. In the subsampling mode, input signals are first 2 to 1 subsampled and coded by the first VQ module. Discarded pels may be interpolative predicted based on the already coded pels by the first VQ module. Prediction error signals are then coded by the second VQ module.

4. Control

Coding and quantizing parameters listed below are controlled to keep the generated information quantity in an appropriate range.

- quantization characteristics for C-component
- quantization characteristics for F-component
- threshold value for significant/insignificant judgement
- number of omitted frames
  (how to treat the skipped frames is for further study)
- spatial subsampling

Both of feed-forward and feedback controls are employed. These controls are performed using the buffer memory occupancy and other factors such as the ratio of significant blocks in the whole frame and so on.

5. Information to be Transmitted

Following information should be transmitted.

- significant/insignificant block identification
- identification flag of combination of VQ and SQ
- motion vector
- index for C-components
  vector quantizing set index
- index for F-components
  scalar quantizing index
  (magnitude for non-zero element and run-length for zero element)
- identification flag of spatial subsampling

6. Simulation Results

Annex presents an example of simulation results. Outline of experimented coding method, coding parameters and some characteristics such as bit allocation for each transmitted information are shown in Annex. Examples of decoded pictures will be demonstrated in the meeting.

7. Conclusion

The current status of the VQ-based coding algorithm study was described. One example was demonstrated to show the capability of the VQ approach, still leaving the treatment of spatial subsampling for further study. This contribution also showed the approach to realize the total coding system by connecting VQ modules in a hierarchical manner. Further improvement can be expected by the proper treatment of the spatial subsampling.

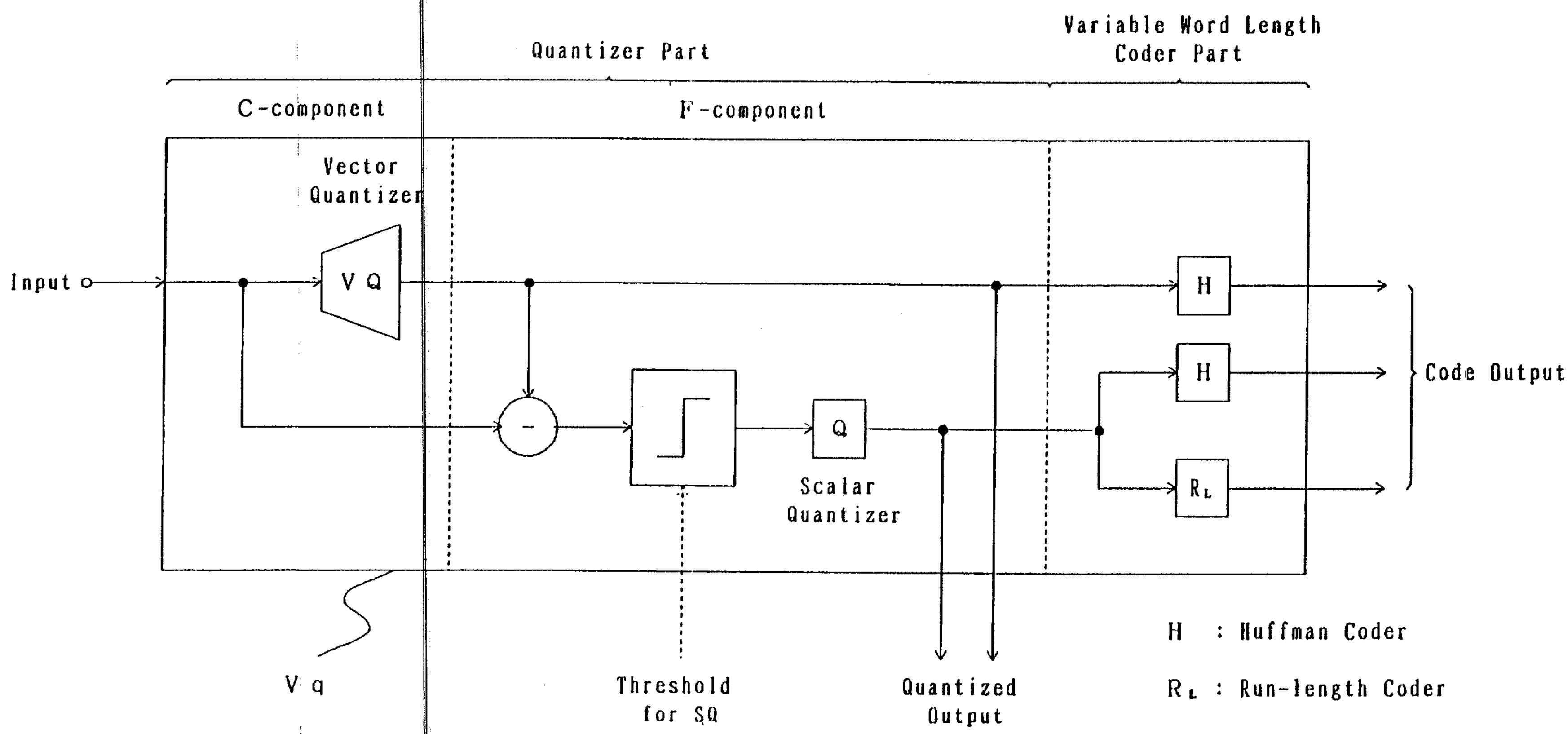


Fig. 1 VQ Coder Module

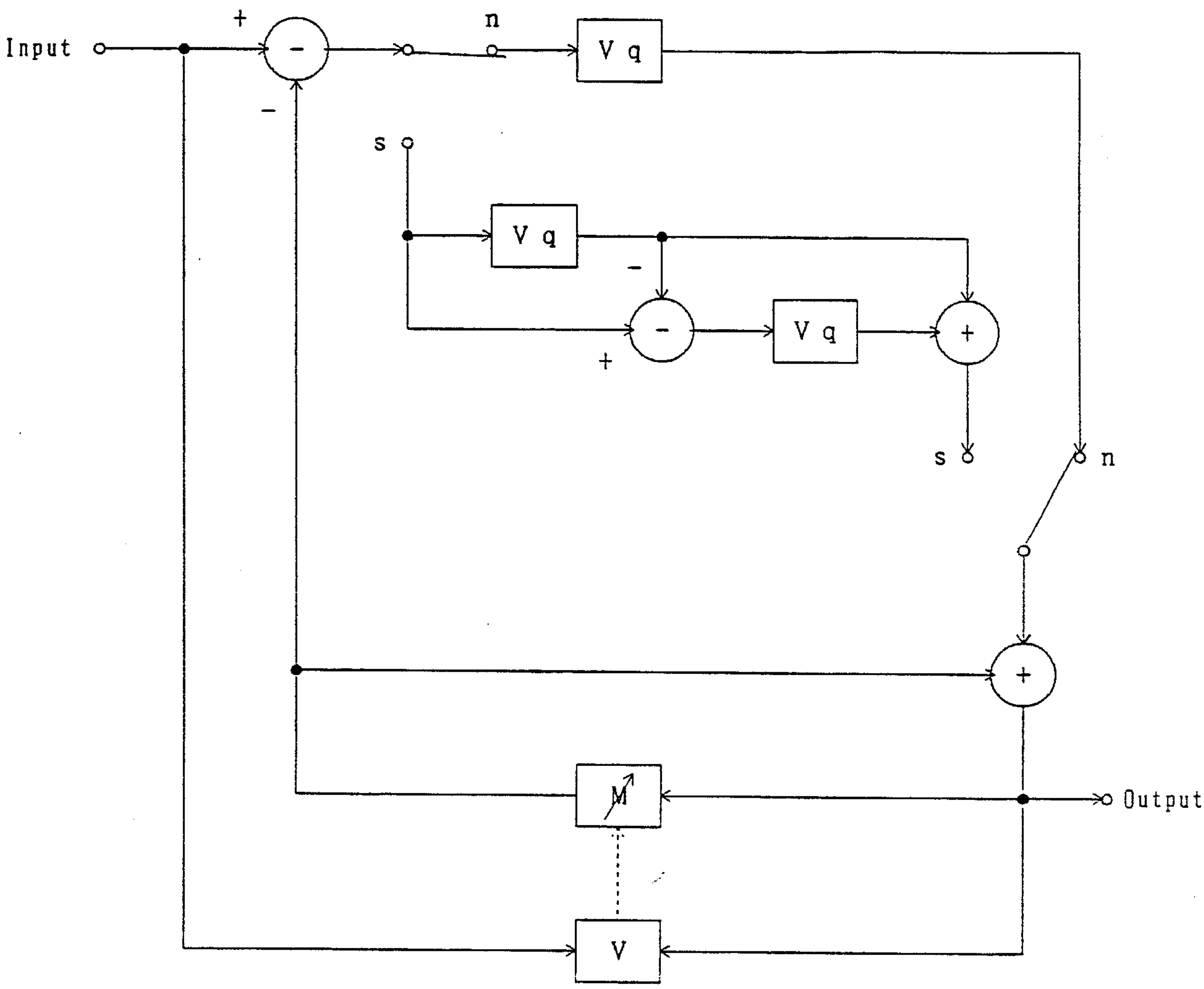


Fig. 2 VQ-based Coder System Configuration

(V q : VQ Coder Module)

Annex to document #62

Simulation Results : VTR

Simulation were carried out on the conditions described below.

1.Mode control

Two coding mode were prepared, namely the normal mode and the scene-change mode.

In the scene-change mode, the judgement is done whether the normal vector quantization or subsampling vector quantization is applied. When the subsampling coding is selected,the following three-step processing was performed:

1. 4:1 subsampling, with pels generating error equivalent to 8/256 or higher being compensated.
2. For the same 4:1 sub-sampled pels, pels generating 2/256 or higher errors were compensated. Where second-step processing was not completed within a single field, the scene was frozen and processing halted until completed.
3. After the second step was completed, if the buffer storage volume was 25% or less of the total, step three was skipped. Step three consists of motion-compensated prediction, with significant compensation where error exceed 8/256 equivalent. (however, setting of this parameter or step seems to be not suitable as you find in the VTR.)

In the normal mode, the quantizer and the threshold values for 4:1 subsampled pels, other 4:1 subsumpled pels, and remaining 2:1 interpolated pels are controlled according to the buffer storage volume. And also threshold determing scalar quantization for remaining VQ signal differential is controlled according to the same strategy. An example of the parameters used in this simulation is indicated in Fig. 1.

2. Coding parameters

Coding parameters not defined in the main body of the contribution were selected as follows.

2.1 Threshold

Fig.1.

2.2 C-coder

Vector set ; 1024 + 1 (0 vector)

Tree search : quarternary branch based on the square error

2.3 F-coder

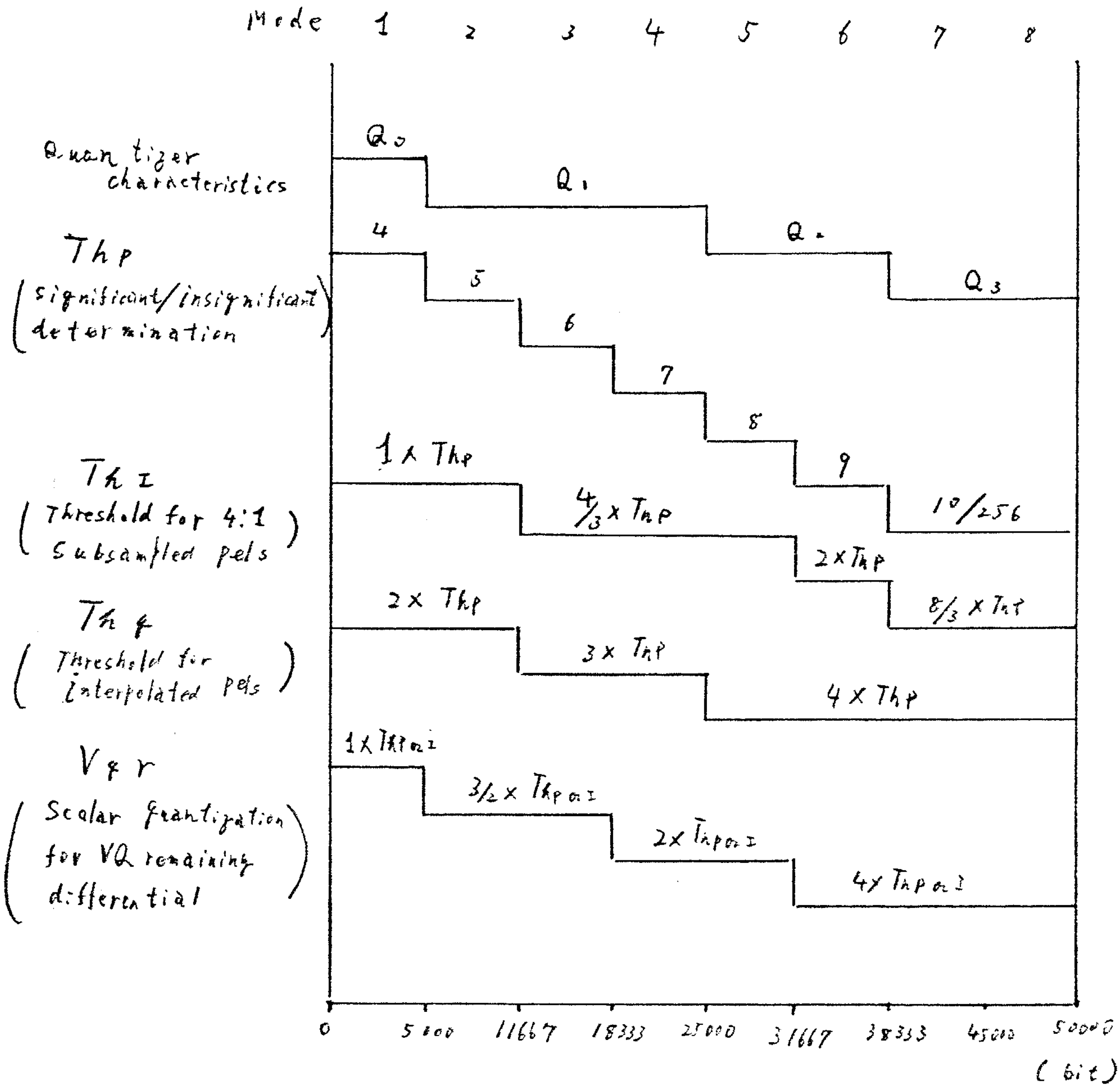
Quantization characteristics : same as Rec. H120 part 3

2.4 Motion vector detection

4 stages hierarchical search

2.5 Other

Motion compensated field interpolative prediction was adopted as option.



note : Significant / insignificant determination is made with the signal power of the predictive error of the entire block. Thp is the value of the threshold used on that determination, converted to the error per pel.

Fig. 1 Parameters for Normal Mode Control

TABLE 1. Bit Assignment (VQ)

UNIT: bit

Data Name	Sig./Insig. & S.S. Mode flag	Motion Vector	C-code VQ	F-code SQ	Total
Miss America (61th frame) [40.16 dB]	3499 8.4 %	8324 20.0%	1566 3.7%	28140 67.9%	41529 100.0%
Checked Jacket (41th frame) [39.13 dB]	3466 9.6 %	4310 11.9 %	1255 3.5%	27036 75.0%	36067 100.0%
Split Screen (24th frame) [31.67 dB]	4871 13.3%	10493 28.7%	3749 10.2%	17480 47.8%	36593 100.0%
Trevor (101th frame) [36.65 dB]	3674 10.3%	6800 19.1%	23679 6.7%	22777 63.9%	35620 100.0%

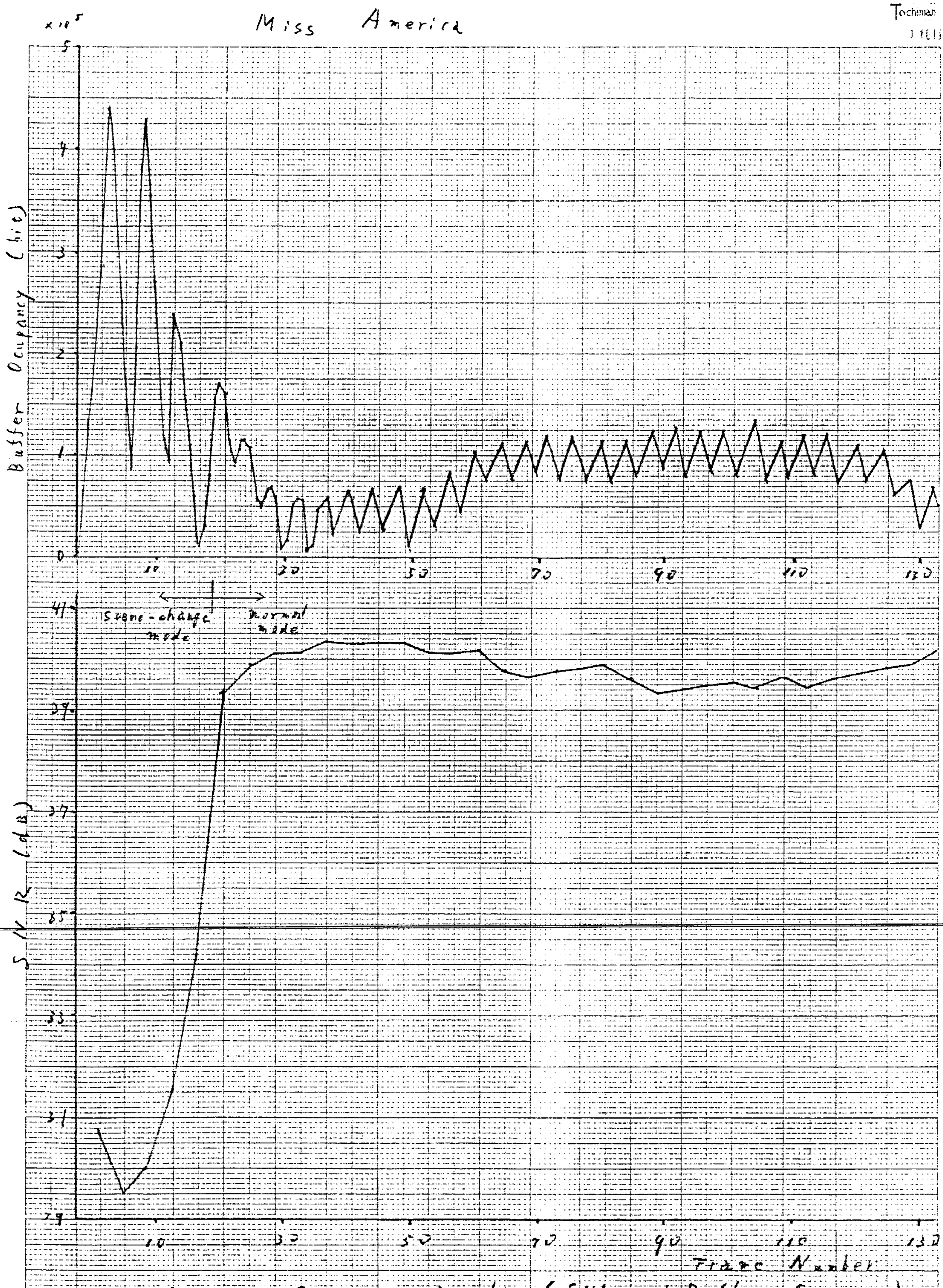


Fig. 2 Simulation Results (SNR and Buffer Occupancy)

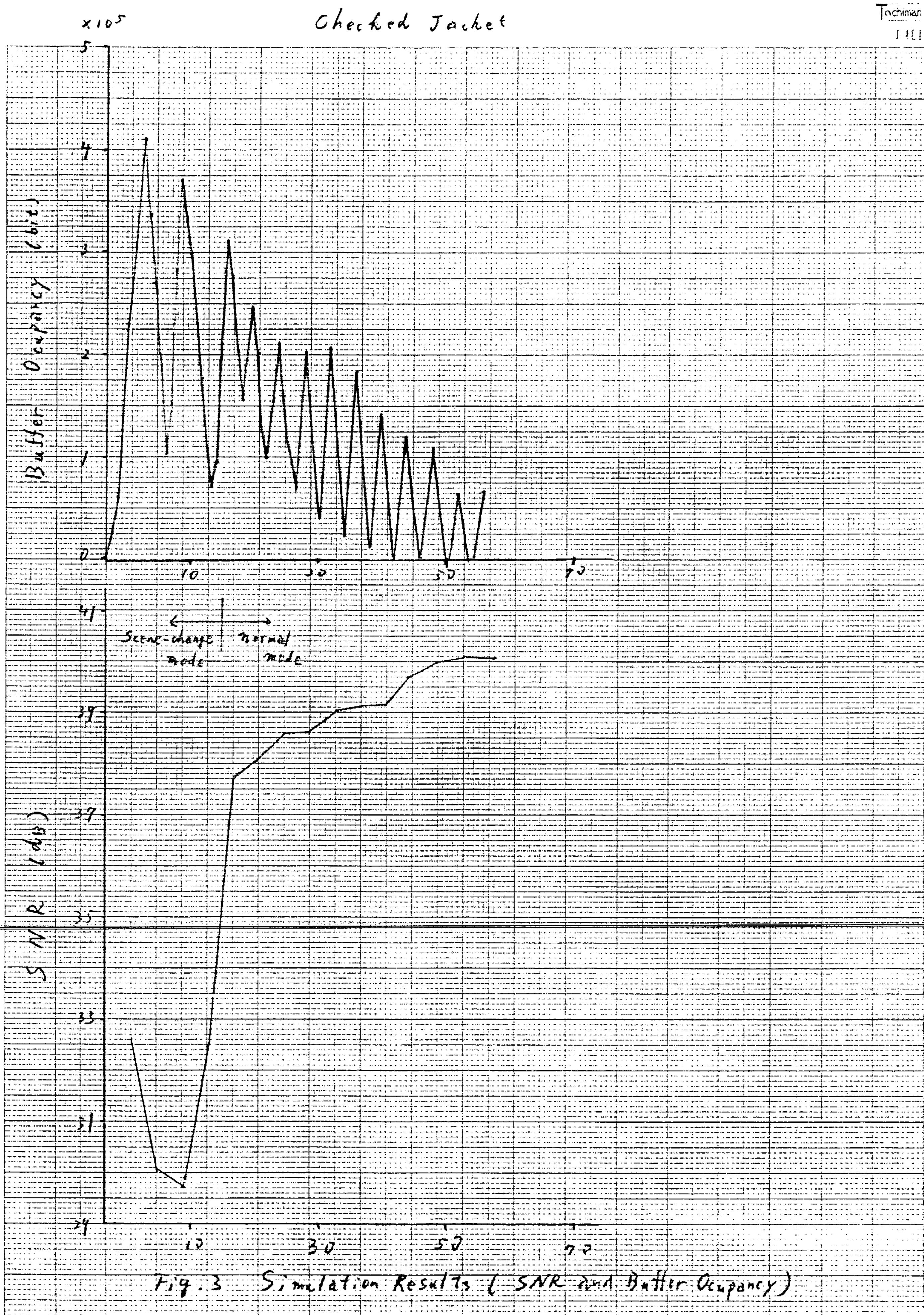


Fig. 3 Simulation Results (SNR and Buffer Ocupancy)

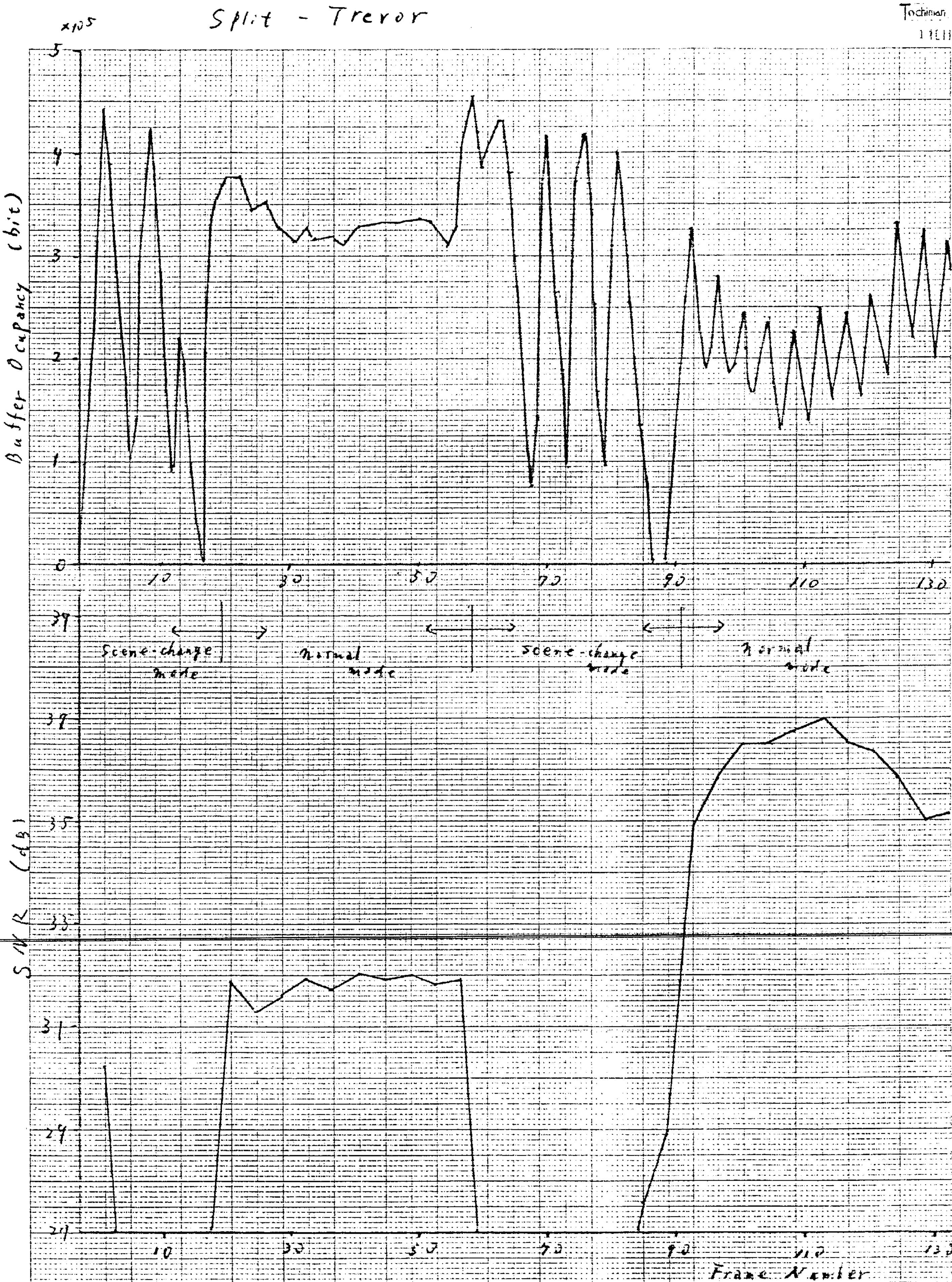


Fig. 4 Simulation Results (SNR and Buffer Ocupancy)