ON THE PROPERTY AND CONFIGURATION
OF THE MULTI-CHANNEL COMPANDER

マルチチャネルコンパンダの特性と構造

Masahichi Kishi[†] Kuixi Yin[††]

岸 政七,   殷 奎 喜

ABSTRACT According to increase of social and economical activity, the mobile communication system is forced on the practical stage of extremely large number of radio channels and is required to reduce occupancy of coverage area for each channel. Compander have prevented from such degradation of speach quality via reducing transmission power as fading and thermal noise.

In this paper, a nobel compander is proposed with basis on Short Time DFT (ab. in ST-DFT) which consists of N/2-1 sub-module along the frequency index of the ST-DFT.

Both the configuration and frequency responses of the ST-DFT multi-channel feed-forward compander (ab. in MC-FF compander) are discussed through computer simulation on CRAY X-MP/14se at AIT.

1. INTRODUCTION

As well known, the syllabic companders operate to improve speach quality with installing compressor at transmission front-end and expander at receiving tail-end. Therefore, many investigations are keenly studied on realizing the syllabic companders. Unfortunately, most of them have been concerned with approximation in detecting voice envelopes. Where such approximated envelope detector is adopted to compressor/expander, the intermodulation error in approximately estimated envelopes induces harmonic distortions.

† 愛知工業大学情報通信工学科 (豊田市)
†† 南京師範大学 (中国江蘇省南京)

2. PRINCIPLE AND CIRCUITRY CONFIGURATION

Figure 1 shows the block diagram of the MC-FF compander, whose details are also schemed in fig.2. Both compressor and expander shown in fig.1 are categorized into three major functional blocks.

The first block shows a ST-DFT analyzer whose sub-module consists of complex multiplyer and proto-type low-pass filter. The block produces instantaneous spectrum components $\phi_k(n)$ from the input signal data x(n). The instantaneous spectrum components $\phi_k(n)$ is given by eq.1,

$$\phi_k(n) = \sum_{m=0}^{N-1} x_m(n) W_N^{-rk} , \qquad (1)$$

where,

$$x_m(n) = \sum_{\ell=-\infty}^{\infty} x(n+lN+[m-n]_N) \, h(-lN-[m-n]_N),$$

$$W_N^{-rk} = \exp(-j2\pi rk/N),$$

The second block shown in details in fig.2 acts as compressing/expanding on the frequency domain. In fig.2(a), a divider is equiped if sub-module operates as a compressor, a multiplyer is equiped in fig.2(a) if sub-module operates as a expander. The compressed/expanded instantaneous spectrum component $\widetilde{\phi}_k(n)$ is given by,

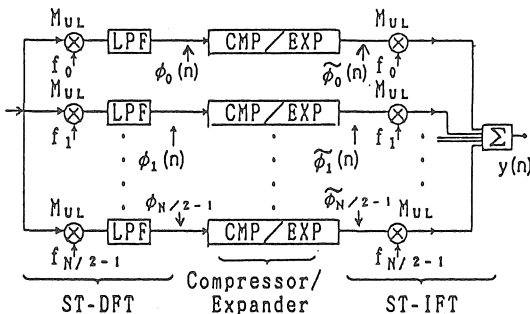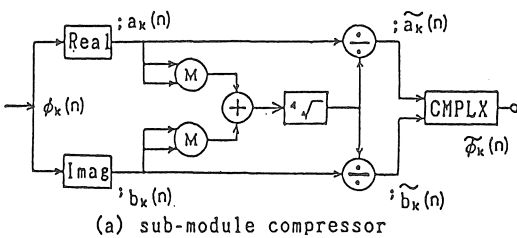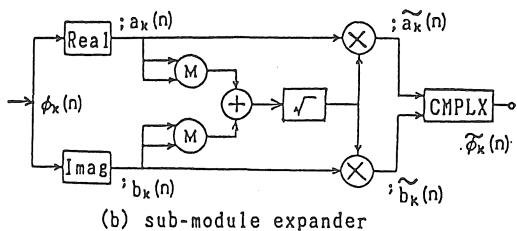$$\widetilde{\phi}_k(n) = |\phi_k(n)|^{\alpha-1} e^{-j\theta_k(n)}, \qquad (2)$$

Fig.1 Block Diagram of The MC-FF Compander

(a) sub-module compressor

(b) sub-module expander

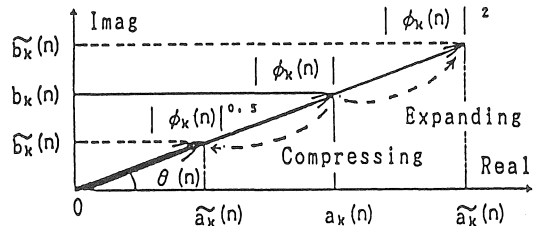Fig.2 Detailed Scheme for the sub-module of the MC-FF Compander

Where α is set to be 0.5 for compressor, and to be 2 for expander. The real part or imaginary of the companded instantaneous spectrum $\widetilde{a}_k(n)$ or $\widetilde{b}_k(n)$ is given as follows,

$$\widetilde{a}_k(n) = |\phi_k(n)| \cos\theta_k(n) = |\phi_k(n)|^{\alpha-1} a_k(n), \quad (3)$$

$$\widetilde{b}_k(n) = |\phi_k(n)| \sin\theta_k(n) = |\phi_k(n)|^{\alpha-1} b_k(n), \quad (4)$$

where $\theta_k(n)$ is defined by '

$$\theta_k(n) = \tan^{-1}\{a_k(n)/b_k(n)\} \qquad (5)$$

Therefore, the second blocks is schemed as shown in fig.2 of companding the instantaneous spectrum on the frequency domain as shown in fig.3.

The last block is the Short Time DFT, i.e. ST-DFT synthesizer, which reproduces companded signals y(n) from the companded instantaneous component $\widetilde{\phi}_k(n)$.

The companded signals, y(n) are given by,

$$y(n) = \frac{1}{N} \sum_{k=0}^{N-1} \widetilde{\phi}_k(n) W_N^{nk} \qquad (6)$$

where,

$$W_N^{nk} = \exp(j2\pi nk/N)$$

Fig.3 The companding on the frequency domain

3. EXPERIMENT RESULTS

All of the compander experiments are performed through computer simulations on the super-computer CRAY X-MP/14SE at AIT to avoid any round-off errors. The experiments

were held on the conditions as follows.

The window function frame number 2m is set to be 8 and frame length N is set to be 32, 64 or 128, respectively. All of spectrums are observed via ST-DFT of N=8192. Harmonic distortion of the ST-DFT compander is observed to be below -80 dBm at 800 Hz 0 dBm tonal input signal. Where the CCITT G.162 defines the harmonic distortion being below -28 dB, the ST-DFT compander with below -80 dB harmonic distortion is substantially realixed to be ideal.

The signal to distortion ratio (ab. in SDR) is shown in fig.4 for the 0 dBm input signals uon the range from 300 Hz to 3.4 kHz. Solid line shows SDR for ST-DFT compressor of N=64, dotted line shows for N=32. The SDR of existing syllabic companders is also shown by chained line in fig.4 for comparison with ST-DFT companders.
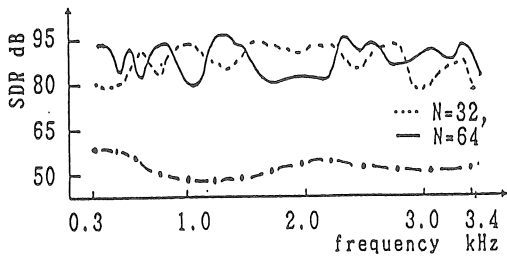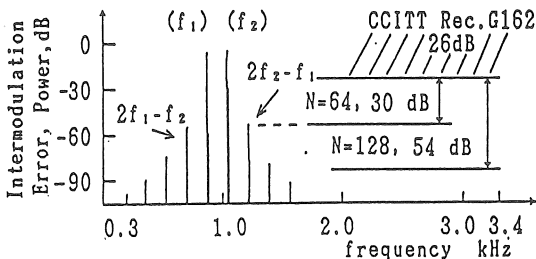

Fig.4 SDR of The MC-FF Compressor

Fig.5 Intermodulation Error of the MC-FF Compressor

As shown in fig.4, the SDRs of ST-DFT companders are improved by more than 20 dB from that of existing syllabic companders on almost all the frequency range.

Intermodulation among where the some condition of the CCITT G162 of 900 Hz -5 dBm and 1020 Hz -5 dBm tonal signals is observed as shown in fig.5. The intermodulation error of the MC-FF compressor is below -55 dB if N=64, and below -80 dB if N=64, and below -80 dB if N=128, where CCITT G162 recommends intermodulation error should be below -26 dB.

4. CONCLUSION

The experiment results showed that the short time DFT is so useful in signal processing as the multi-channel feed-forward compander being almost free from the harmonic distortions. Instead of great deal of processing in companding, the MC-FF compander. will be put on the stage of developments from the superior characteristics as discussed aboves.

REFERENCE

1. M. Kishi, "The Properties and Configuration of the ST-DFT Hilbert Transformers", IEEE ICASSP89, Glasgow, proc. Vol.2, D4.10, pp.1019-1021, May 1989.