stage, the fast procedure based on diagonal approximation is performed, and, in the second stage, searching is performed on M codewords which have an HD of 1 with reference to the codeword obtained in the first stage.

Table 1: Percentange occurrence of Hamming distances of codewords obtained using exhaustive search and proposed fast search

Hamming Distance	0	1	2	3	4	5
Codebook 1	41.3	41.9	13.9	2.7	0.2	0
Codebook 2	46.7	38.9	12.8	1.6	0	0

To compare the SNR performance of VSELP coders using the proposed fast procedure and the conventional Gray code search procedure, we implemented several coders based on the 7.95kbit/s VSELP coder defined in [2]. Table 2 shows the SNR performance and the codebook search complexity of these coders. In this test, coder 1 is a standard VSELP coder which uses Gray code searching. Coder 2 uses the fast sign detection (SD) procedure without HD-1 correction. Coder 3 uses the fast SD procedure with HD-1 correction. Coder 4 uses the fast SD procedure with two HD-1 corrections applied sequentially. Note that the encoding format of IS-54 will not be altered even though the proposed search procedure is employed.

Table 2: Comparison of SNR and complexity for VSELP coders using Gray code and proposed fast search procedures

	Coder 1 Gray code search	Coder 2 SD search only	Coder 2 SD search plus HD-1 correction	Coder 3 SD search plus two seq. HD-1 corrections
SNR	14.10	13.55	13.88	14.05
Search Complexity	$M2^M$	M	2M	3M

Surprisingly, the results indicate that, even using the fast sign detection procedure without HD-1 correction, the SNR is only 0.55dB lower than that achieved using Gray code searching. By using HD-1 correction, the SNR degradation is only 0.22dB. We have also performed several listening tests and the listeners commented that they can hardly tell the difference in speech quality for all VSELP coders tested.

Conclusion: This Letter presents a more efficient codebook search method for vector-sum excited linear predictive coding of speech. The method uses a two-stage search procedure where a simple sign detection procedure is used in the first stage and an HD-1 correction procedure is used in the second stage. The complexity of the proposed method is only proportional to the bit rate but not proportional to codebook size as in conventional VSELP coders. Simulation results showed that the performance achieved using the proposed method is the same as that achieved using Gray code searching.

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Efficient frequency assignment scheme for intermodulation distortion reduction in fibre-optic microcellular systems

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Indexing terms: Cellular radio, Frequency allocation

An efficient and effective frequency assignment scheme for fibre-optic microcellular systems is presented. The scheme is suitable for intermodulation distortion reduction in multichannel transmission systems. The computation time reduction is quite substantial with good intermodulation distortion reduction.

Introduction: In subcarrier-multiplexed fibre-optic microcellular systems [1], each microcell is responsible for handling a set of frequency channels. Adjacent channel interference is a large problem that degrades the carrier-to-interference ratio of the channels when the set of channels passes through some nonlinear devices. The spurious intermodulation distortion components interfere with the signals and thus degrade the signal quality. One method for overcoming this problem is to assign the carrier frequencies in such a way that the intermodulation distortions do not fall onto any of the signal channels in use. This is simple and does not demand a great amount of hardware. In this Letter, an efficient and effective algorithm is proposed to assign the frequencies in a proficient way to minimise the distortion components falling onto the channel carriers, and thus improve the signal quality.

Algorithm: In our analysis, only the third-order intermodulation distortion (IMD) terms are considered because they form the largest proportion of the overall intermodulation distortion in the system. There are two kinds of third-order IMD; triple beat ($f_i + f_j - f_k$) and two-tone third-order ($2f_i - f_j$) for distinct frequencies f_i, f_j, and f_k. A parameter, IM-advantage, is defined as the ratio of the number of IMD terms in the worst-case occupied slot when the carriers are equally-spaced to that when the frequency assignment is used for the carriers; this parameter is commonly used to assess the quality of an assignment.

In [2], an efficient algorithm, DEIN, was proposed for satellite systems. In view of the fact that the number of IMD terms is proportional to the number of carriers in the link, another algorithm [3] (FP), was proposed to assign the carriers to multiple links. However, excessive computation time is required because it examines all possibilities in insertion and deletion operations. Therefore, we propose a new algorithm to reduce the computation time needed.

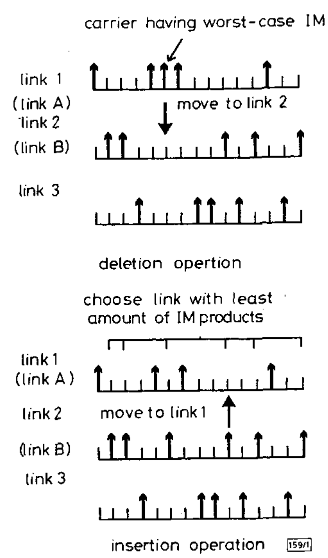

Fig. 1 *Deletion operation and insertion opertion of MDI algorithm in three-link case*

In our algorithm, multiple links are used and the deletion/insertion operations are adopted iteratively. For N carriers to be assigned to m links, each link will have (N/m) carriers. In a frequency slot in all links, at most one link can have an occupied slot. In each iteration, two links will be chosen for performing the insertion and deletion operations (see Fig. 1). For a deletion operation, the link having the greatest worst-case IMD of all links is chosen as link A. The carrier in the worst-case slot in link A is deleted and moved into the same slot of another link (link B) which will have the smallest increase in worst-case IMD of all other links. An insertion operation is then performed. An unoccupied slot in link A is chosen such that it experiences the least amount of IMD in link A and that corresponding slot in link B is occupied. The carrier in that slot in link B is moved to link A. This process is repeated until there is no further improvement in the distortion reduction. This algorithm is called MDI (multiple delete/insert).

Table 1: IM-advantage and computation time for different carriers using FP and MDI algorithm in three-link case

Number of channels	Number of links = 3			
	IM-advantage		Computation time	
	FP	MDI	FP	MDI
	dB	dB	s	s
30	5.28	5.28	15	1
45	5.10	4.52	158	8
60	5.05	5.05	993	37
75	5.10	4.47	3886	72
90	4.79	4.87	9134	219
105	4.69	4.84	23631	535
120	4.63	4.82	42974	905

Computation results: The algorithm MDI is implemented using DEC3100 workstations and the results (IM-advantage and computation time) are compared with the FP algorithm [3]. Table 1 shows the results of different number of carriers with three links by using the FP and MDI algorithms. It is shown that the IM-advantage is about the same in both algorithms. Considering the computation time, which is a measure of the efficiency of the algorithm, the MDI algorithm requires much less computation time than FP. The reduction in computation time for the MDI algorithm is even better for a greater number of carriers, about 16.6dB for the case of 120 carriers in three links. So, the MDI algorithm is quite effective and efficient at intermodulation reduction.

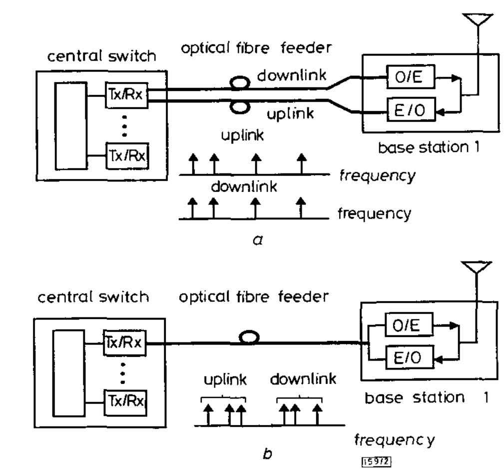

Fig. 2 *Two optical fibre feeder configurations*

Application in fibre-optic microcellular systems: The MDI algorithm can be applied to fibre-optic microcellular systems. In such systems, each microcell has a base station and is responsible for handling a subset of frequency channels. The base stations are connected to the central switch through separate fibre-optic links in two possible configurations. The first configuration (see Fig. 2*a*) has two separate fibre links handling the same corresponding subset of frequency channels between each base station and the central switch. One is for uplink signal transmission and the other is for downlink operation. In this case, the previously described MDI algorithm can be used for frequency assignment for all carriers in all links for all microcells. The second configuration (see Fig. 2*b*) has only one fibre link between each base station and the central switch. The whole RF spectrum is split into two distinct frequency bands. One of them holds all the uplink carriers while the other holds all the downlink carriers. This is feasible because optical fibres have extremely large bandwidth. In this case, the MDI algorithm may be applied to each frequency band to perform frequency assignment for the carriers among all links simultaneously with the consideration of the intermodulation distortion contributed from the other frequency band. In general, the MDI algorithm can be used at the central switch to perform frequency assignment for each microcell because it operates in the multiple-link case and the carrier frequencies in all links are mutually exclusive. In this way, intermodulation distortions present in the base stations, as well as along the fibre-optic links with some nonlinear devices such as laser diodes, can be minimised. The time required for system reconfiguration is considerably reduced due to the efficiency of the algorithm.

Conclusion: An efficient algorithm, MDI, was proposed for frequency assignment in fibre-optic microcellular systems. It features a substantial decrease in computation time with good intermodulation distortion reduction. Its efficiency is quite advantageous in system reconfigurations. It can further be applied to frequency planning in other multichannel transmission systems such as single channel per carrier satellite systems and CATV distribution systems.

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New class of codes based on two-dimensional Fourier transforms over finite fields

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Indexing terms: Error correction codes, Number theoretic transforms, Reed-Solomon codes

A new class of two-dimensional codes is proposed, which is based on two-dimensional Fourier transforms over a finite field. The code length of the proposed codes over $GF(q)$ is $(q-1)^2$ while that of nonsystematic Reed-Solomon codes over $GF(q)$ is $q-1$.

Introduction: Many error-correcting codes [1] have been developed to enhance the reliability of data transmission systems and memory systems. One class of superior error-correcting codes is Reed-Solomon codes [2], which are constructed based on one-dimensional Fourier transforms over a finite field [3]. In this Letter, I show that a new class of two-dimensional codes can be constructed based on two-dimensional Fourier transform over a finite field.