Experiment No-6

Aim-To Study and Implement Walsh Codes using Hadamard Matrix

Software-Octave/Matlab

Theory-

Walsh codes, derived from the Hadamard matrix, are mutually orthogonal binary codes used in CDMA systems. The orthogonality property means that the dot product between any two distinct Walsh codes is zero. This ensures that each user's data in a multi-user system does not interfere with others.

1. Hadamard Matrix: A Hadamard matrix is a square matrix with entries +1 and −1 such that any two distinct rows (or columns) are orthogonal. For a matrix Hn , orthogonality means:

   Dot product of row $i$and row j=0 for $i \neq j$

The Hadamard matrix of order n is generated recursively as:

$$H_n = \begin{bmatrix} H_{n/2} & H_{n/2} \\ H_{n/2} & -H_{n/2} \end{bmatrix}$$

2. Orthogonality Check: The orthogonality of Walsh codes is mathematically verified by taking the dot product of two distinct rows from the Hadamard matrix. If the dot product is zero, the two Walsh codes are orthogonal:

$$W_i \cdot W_j = 0 \quad \text{for } i \neq j$$

Procedure:

1.Generate the Hadamard Matrix: Begin by generating a Hadamard matrix of the desired order n, which is a power of

2. Extract the rows of the matrix as Walsh codes.Select Walsh Codes for Orthogonality Check: Select two distinct Walsh codes (rows from the Hadamard matrix) for which orthogonality needs to be verified.

3. Compute Dot Product: Perform the dot product operation between the selected Walsh codes. If the result is zero, the codes are orthogonal. If it is non-zero, they are not orthogonal.

Example:

Step 1: Generate the Hadamard Matrix of Order 4.

$$H_4 = \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 \end{bmatrix}$$

Step 2: Select Walsh Codes. Let's select two rows from the matrix:

- $W_1 = [1, 1, 1, 1]$
- $W_2 = [1, -1, 1, -1]$

Step 3: Compute the Dot Product. The dot product of W_1 and W_2 is calculated as:

$$W_1 \cdot W_2 = (1 \times 1) + (1 \times -1) + (1 \times 1) + (1 \times -1) = 1 - 1 + 1 - 1 = 0$$

Since the dot product is zero, the Walsh codes W_1 and W_2 are orthogonal.

Conclusion-