Low Complexity Reconfigurable Variable WALSH Code for Multi Standard Wireless Front End Receivers

D.Saranya¹, T.Shanthi²

Student¹, Faculty²

Department of Electronics & Communication Engineering
Kings College of Engineering, Punalkulam-613 303, Thanjavur, Tamilnadu, India.
saranyasumi20@gmail.com¹, aravindshanthi@yahoo.co.in²

Abstract:

The low-complexity reconfigurable Variable Walsh Code tree (VWCT) for wireless communication applications such as spectrum sensing and channelization. In VWCT, the bandwidth and center frequency of sub-bands can be varied with high frequency resolution without hardware reimplementation. The proposed a simple technique to construct Walsh code sets of any length recursively using 4-bit Gray and Inverse Gray codes. An n-bit Gray code is a list of all 2n bit strings such that adjacent code words in the sequence differ in only one bit position. The technique presented in this problem allows us to construct 4!=64 Walsh code set (of any length) orderings since they are constructed from 4-bit Gray and Inverse Gray codes. All these Walsh code sets are not symmetrical along rows and columns. A Gray-Binary mapping technique is adopted to transform these Walsh code sets into symmetrical matrices.

Keywords—Fast Filter bank (FFB), Variable Walsh tree (VWCT), variable digital filter (VDF), Direct Sequence Code Division Multiple Access (DS-CDMA), Long Term Evolution (LTE).

I. INTRODUCTION

The most computationally demanding part in the digital front-end of a Software radio receiver is the channelizer, which operates at the highest sampling rate. The channelizer extracts multiple narrowband channels from the digitized wideband input signal. The limitation of the conventional uniform Discrete Fourier transform (DFT) filter bank channelizer is that, it is incapable of extracting channels of multiple bandwidths, as the prototype filter has fixed equal bandwidths. Reconfigurable filter bank architecture for the SDR channelizer, based on multi-stage frequency response masking technique is proposed¹. The proposed architecture is capable of extracting channels with different bandwidths corresponding to different wireless communication standards. Design examples show that proposed architecture offers a complexity reduction of 97.2 % over the conventional Per-Channel (PC) approach and DFT filter banks. A simple technique to construct the walsh codes are fixed length orthogonal codes possessing high auto correlation and low cross correlation properties¹. It has linear phase and zero mean with unique number of zero crossings for each sequence within the set. It is commonly used as spreading sequences in Direct Sequence Spread Spectrum (DS-SS) communications. And the backbone of CDMA systems and are used to develop the individual channels. Channelization by means of code multiplexing is a fundamental feature of IS-95 systems³.In particular, channelization is accomplished using length-64 Walsh codes, which are assigned to different channels. Walsh codes can be generated recursively and indexed according to their row number in the M by M Walsh matrix.

II. OVERVIEW OF CDMA TECHNIQUE

In DS-CDMA system, for despreading operation, the received data should multiplied with the same code in the receiver. So the other user codes in the same frequency band must be uncorrelated with the desired user code. For this reason the DS-CDMA codes have to be designed so as to possess very low cross-correlation. Auto-correlation shows the measure of similarity between the code and it’s cyclic shifted copy. Because of this reason, the codes that have the best properties of auto-correlation have frequently been used in removing the asynchronous in communication systems. The auto-correlation can be reffered to (1a) and (2b)

\[ R_c(k) = \sum_{n=1}^{N} a_n a_{n+k} \]  

1a

\[ R_c(k) = \sum_{n=1}^{N} a_n b_{n+k} \]  

2b

Cross-correlation is the measure of similarity between two different codes. In other words cross-correlation describes the interference between codes a_n and b_n.

III. EXISTING FOR RFFB FRONT-END RECEIVER

The RFFB is designed to provide fine control over the sub-band bandwidth. Let the design specifications of the RFFB
with L sub-bands be: minimum and maximum sub-band bandwidth as BWmin and BWmax, respectively, desired TBW as TBWd, pass-band ripple as $\partial p$, stop-band attenuation as $\partial s$. All the frequency specifications mentioned here are normalized with respect to half the sampling frequency. The structure of the RFFB with $k = (\log_2(L))$ stages is shown in Figure 1, where M is the interpolation factor for the first stage and equal to $L/2$.

**FIGURE 1**
EXISTING RFFB

The low-pass VDF in the first stage is designed using modified second-order frequency transformation with transfer function $H_2(Z)$ in the form given by (3). The range over which cutoff frequency of $H_2(Z)$ can be varied is decided by parameters $A_1$ and $A_2$, while the order of the prototype filter of $H_2(Z)$ is decided by its TBW, pass-band ripple, and stop-band attenuation specifications. Expanding $D(Z)$ in (3), we have

$$D(Z) = A_0 Z^{-2} + A_1 Z^{-1} \left( \frac{1 + Z^{-2}}{2} \right) A_2 \left( \frac{1 + Z^{-2}}{2} \right)^2$$

**IV. PROPOSED VARIABLE WALSH CODE FRONT-END RECEIVER**

The exponential growth of mobile data has driven up the need of more wireless spectrum. As diverse and fragmented spectrum bands that span from low to high need to be supported on a device, it presents a dramatic challenge to handset RF front-end design and architecture. To further this challenge, market forces are also driving handsets to meet the following complex requirements: multi-band (for domestic & international roaming) and multi-mode (2G/3G/4G, Assisted Global Positioning System (AGPS), WiFi/Bluetooth (BT)).

**FIGURE 2**
PROPOSED WALSH CODE TREE

Near Field Communications (NFC), Multi-Input Multi-Output (MIMO) and carrier aggregation, small form factor (thinner ID, larger display, etc.) while balancing cost competitiveness, ever better performance, longer battery life and regulatory requirements (i.e., Specific Absorption Rate (SAR)). As such, RF Front-End must be optimized for the benefit of stakeholders and end customers.

An optimized RF Front-End design and architecture can be very helpful to meet all these challenges and facilitate adoption of 3rd Generation Partnership Project (3GPP) mobile broadband technologies in all appropriate frequency bands.

**WALSH CODE TREE**

A simple technique to construct the walsh codes are fixed length orthogonal codes possessing high auto correlation and low cross correlation properties. It has linear phase and zero mean with unique number of zero crossings for each sequence within the set. It is commonly used as spreading sequences in Direct Sequence Spread Spectrum (DS-SS) communications. And the backbone of CDMA systems and are used to develop the individual channels. Channelization by means of code multiplexing is a fundamental feature of IS-95 systems. In particular, channelization is accomplished using length-64 Walsh codes, which are assigned to different channels.

**SPREADING CODES**

In DS-CDMA system, for despreading operation, the received data should multiplied with the same code in the receiver. So the other user codes in the same frequency band must be uncorrelated with the desired user code. For this reason the DS-CDMA codes have to be designed so as to posses very low cross-correlation. Auto-correlation shows the measure of similarity between the code and it’s cyclic shifted copy. Because of this reason, the codes that have the best properties of auto-correlation have frequently been used in removing the asynchronous in communication systems.
The auto-correlation can be referenced to (2a),

$$R_C(k) = \sum_{n=1}^{N} a_n a_{n+k} \quad (2a)$$

Cross-correlation is the measure of similarity between two different codes. In other words, cross-correlation describes the interference between codes $a_n$ and $b_n$, referenced to (2b)

$$R_C(k) = \sum_{n=1}^{N} a_n b_{n+k} \quad (2b)$$

Where $a_n$ and $b_n$ are the elements of two different codes and have period $N$.

As it is known, all users in a CDMA system are multiplied by a code sequence that has a chip rate greater than the data rate. The way to orthogonalize the users is, multiplying each user’s binary input by a short spread sequence which is orthogonal to all other users of the same cell. The short orthogonal codes are called channelization codes.

As was described, it is possible to pinpoint the resulting intermediate frequencies, $\text{IF}$, relationship can be referenced to (4a)

$$f_{\text{IF}}(a) = \text{fix}\left(\frac{f_c}{f_s/2}\right)$$

where $f_c$ is the carrier frequency, $f_s$ is the sampling frequency, $\text{fix}(a)$ is the truncated portion of argument $a$, and $\text{rem}(a,b)$ is the remainder after division of $a$ by $b$. In this case, the RF band-pass signal filtering plays an important role because it must reduce all signal energy (essentially noise) outside the Nyquist zone of the desired frequency band that otherwise would be aliased. If not filtered, the signal energy (noise) outside the desired Nyquist zone is folded back to the first zone together with the desired signal, producing a degradation of the signal to noise ratio ($\text{SNR}$) can be referenced to (4b)

$$\text{SNR} = 10 \log_{10}\left(\frac{s}{N_0+(n-1)N_0}\right) \quad (4b)$$
where $S$ represents the desired-signal power, $N_i$ and $N_0$ are in-band and out-of-band noise, respectively, and $n$ is the number of aliased Nyquist zones. The advantage of this configuration is the sampling frequency needed and the subsequent processing rate are proportional to the information bandwidth, rather than to the carrier frequency. This reduces the number of components required. However, some critical requirements exist. For example, the analogue input bandwidth of the sample and hold circuit inside the ADC must include the RF carrier, which is a serious problem, considering the sampling rate of modern ADCs. Clock jitter can also be a vital problem when high frequencies implementations are considered.

V SIMULATION RESULTS

8-BIT ADDERS USING VWCT

FIGURE:5
UNIFORM SIGNAL FROM 8 BIT INPUT VALUES FOR DIFFERENT USERS

FIGURE:6
DIFFERENCE OF 8 BIT INPUT VALUES FOR 5 USERS

16x16 BIT MULTIPLIERS USING VWCT

FIGURE:7
UNIFORM SIGNAL FROM 16 BIT WALSH CODE TREE

FIGURE:8
NON-UNIFORM SIGNAL FROM 16 BIT WALSH CODE TREE

VI. CONCLUSION

In this paper we are focus on how to prevent loss and dropped packet, where network coding can offer biggest benefits. In 3G cellular network the question is how they interface with TCP/IP networks. TCP cannot easily distinguish between lost or dropped packets. Loss-free wireless networks are incredibly rare for cellular networks, where installing more base stations is the very expensive solution to packet loss, coded TCP could be a big boon which is implementing in 4G to overcome the limitation of packet loss and dropped.

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The next-generation networks capable of 10 Gbps data speeds within the next seven years. They are focused on the Fifth-generation, or 5G, mobile technology will deliver data speeds 100 times that of the fastest LTE networks, which max out at 100 Mbps when afforded the necessary spectrum.

REFERENCES


