Secondary synchronisation codes (SSC) corresponding to the Generalised Hierarchical Golay (GHG) PSC

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Summary:
In [1] Siemens and Texas instruments have jointly proposed the Generalized Hierarchical Golay (GHG) sequence based upon the pruning of the Golay sequence. In this contribution, we propose the secondary synchronization codes (SSC's) corresponding to the GHG PSC that have good a-periodic cross-correlation properties with the GHG PSC and slightly reduced complexity. The basic comma free code and the Hadamard structure of the SSC's is maintained. The proposed SSC's allow for a better sharing of the hardware between the PSC and SSC while improving the aperiodic cross correlation with the PSC.

1.0 Current SSC

The T.I., Siemens jointly proposed GHG PSC is shown in figure (1):

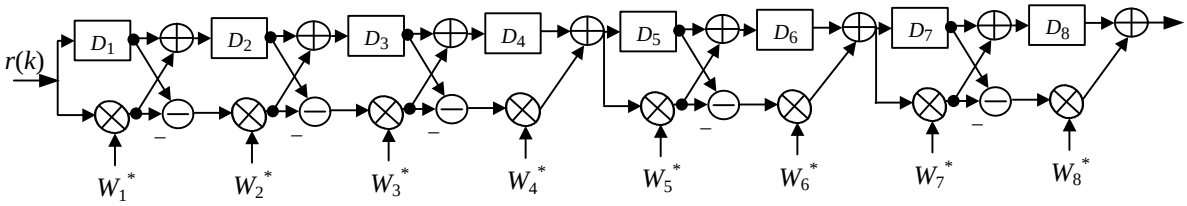

Figure (1): The GHG PSC [1] is shown. The matrix D is given by D = [128, 64, 16, 32, 8, 1, 4, 2] and W = [1, -1, 1, 1, 1, 1, 1, 1].

A block diagram of the current SSC structure corresponding to the GHG [1] is shown in figure (2) below.

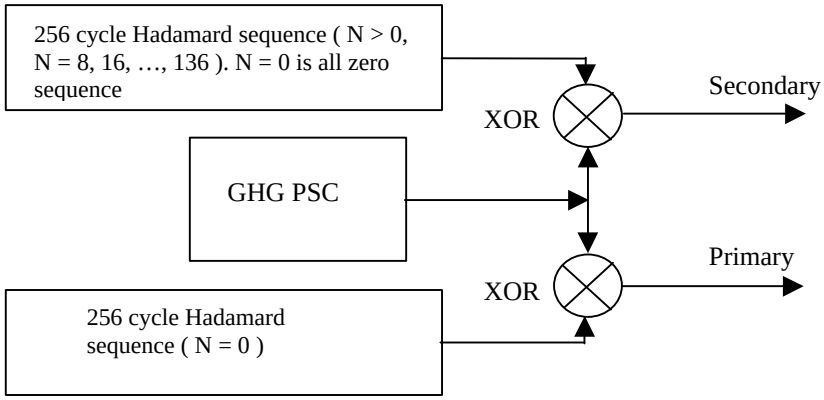

Figure (1): The current SSC structure corresponding to the GHG PSC [1] is shown.

However, we find that the aperiodic cross correlation of the SSC to the PSC for the above codes is not very good. We give the maximum aperiodic side lobes (MAS) of the (PSC+SSC) correlation for the 17 codes given above in table (1) below:

SSC code number	Main peak at frequency error (kHz)		MAS of (GHG PSC + SSC) to GHG PSC, at frequency error (kHz)	
	0 kHz	*10 kHz*	0 kHz	*10 kHz*
1	256	*120*	192	*78*
2	256	*121*	160	*120*
3	256	*121*	88	*84*
4	256	*124*	96	*123*
5	256	*122*	78	*69*
6	256	*124*	160	*123*
7	256	*120*	86	*75*
8	256	*136*	128	*123*
9	256	*124*	88	*73*
10	256	*132*	96	*113*
11	256	*120*	76	*91*
12	256	*136*	192	*122*
13	256	*120*	104	*70*
14	256	*121*	192	*121*
15	256	*120*	142	*61*
16	256	*217*	128	*65*
17	256	*131*	70	*95*

Table 1: MAS of the (GHG PSC + SSC) to the GHG PSC is shown for frequency error = 0, 10 kHz.

We can see from table (1) that the MAS of the PSC+SSC to PSC is quite large. But we have found that this does not have significant degradation in the acquisition performance, largely because of the averaging over the comma free codes. However, it will be better if we have the SSC codes more orthogonal to the PSC implying reduced (PSC+SSC) MAS, without increasing the acquisition complexity. We propose that using Golay based SSC will satisfy the above constraints. Letting A = {+1,+1,+1,+1,+1,+1,-1,-1} and B = {+1,-1,+1,-1,+1,-1,-1,+1} we can see that the GHG PSC is given by *{A, B, A, B, A, B, -A, -B, -A, -B, A, B, -A, -B, -A, -B, A, B, A, B, A, B, -A, -B, A, B, -A, -B, A, B, A, B}*.

By the property of the Golay codes, the PSC correlator in figure (1) can also be implemented as shown in figure (3).

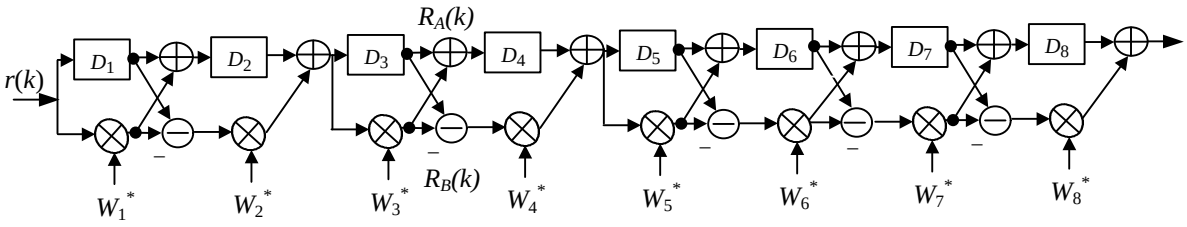

Figure (3): An alternative implementation for the GHG PSC [1] is shown. The matrix D is given by D = [2, 4, 1, 8, 32, 16, 64, 128] and W = [1, 1, 1, 1, 1, 1, -1, 1] and it corresponds to the Hierarchical implementation given in [1].

2.0 Proposed SSC sequences

Let the sequence

Z = {A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A, A} ----------*(1)*

Then our proposed SSC structure is shown in figure (4) below:

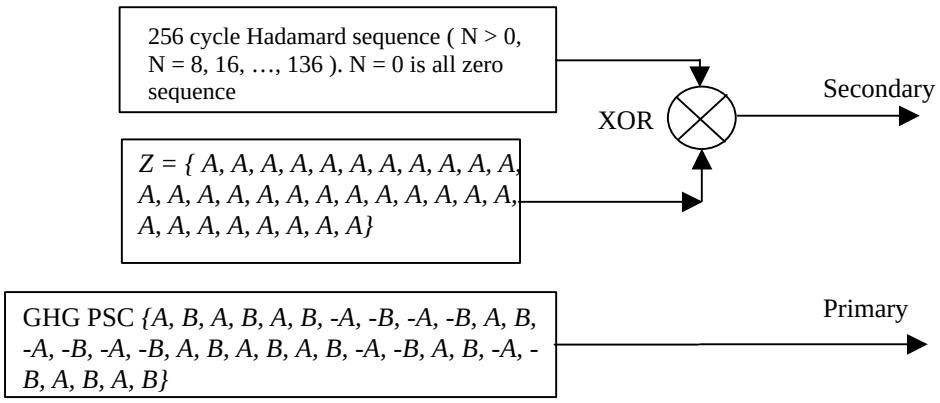

Figure 4: The proposed SSC sequences derived from the Golay sequence A are given.

The MAS of the (GHG PSC + proposed SSC) with the GHG PSC is shown in table (2) below:

SSC code number	Main peak, at frequency error (kHz)		MAS of (GHG PSC + proposed SSC) to GHG PSC, at frequency error (kHz)	
	0 kHz	*10 kHz*	0 kHz	*10 kHz*
1	256	*120*	80	*63*
2	256	*120*	78	*63*
3	256	*120*	80	*63*
4	256	*120*	66	*63*
5	256	*120*	82	*63*
6	256	*120*	78	*63*
7	256	*120*	80	*63*
8	256	*120*	70	*63*
9	256	*120*	80	*63*
10	256	*120*	74	*63*
11	256	*120*	80	*63*
12	256	*120*	70	*63*
13	256	*120*	86	*63*
14	256	*120*	74	*63*
15	256	*120*	80	*63*
16	256	*120*	66	*63*
17	256	*120*	80	*63*

Table 2: MAS of the (GHG PSC + proposed SSC) to the GHG PSC is shown. Comparing to table (1) we can see that the aperiodic auto correlation of the proposed SSC (figure 4) with the GHG PSC is better than the current SSC (table 1).

As for complexity, we can see that the proposed SSC will have slightly lower complexity because it will use only the correlation output $R_A(k)$ in figure (3) as against the current SSC which will need to multiplex with both the outputs $R_A(k)$ and $R_B(k)$. Further, the proposed SSC does not need to do any sign flips as the current SSC will have to, to remove the PSC mask from the SSC.

3.0 Conclusions and proposal

We have proposed a set of new SSC sequences corresponding to the GHG PSC for which the (GHG PSC + proposed SSC) to GHG PSC MAS is much lower. Although, this does not have any impact on the acquisition performance, codes with lower MAS should be preferred. Further, the proposed SSC slightly reduces the stage 2 acquisition complexity. The proposed SSC still employs a Walsh-Hadamard code on top, implying that a Hadamard transform can be used for the stage 2 of acquisition of the proposed SSC's.

References

[1] Siemens, Texas Instruments, "Generalised Hierarchical Golay Sequence for PSC with low complexity correlation using pruned efficient Golay correlators", Tdoc R1-99554, Cheju, Korea, June1-4, 1999.