AAE 575: Satellite Navigation and Positioning

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Homework 01

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Problem 1:

The gold codes, G1 and G2, are a pair of two codes that are generated with the least amount of cross correlation, they are then later used in a cycle and add operation to generate unique codes for satellites. To generate such codes, a set of initial conditions must be set as a sequence of all 1's. That sequence is then used to generate a set of 10 codes each (for G1 and G2) that are length $2^n - 1$. To do this, taps are used to select which positions in the initial sequence are to be added together to replace the first address in the code as the rest of the code is shifted to the right by one index. For G1, the taps are in the 3rd and 10th index, while for G2, the taps are in the 2nd, 3rd, 6th, 8th, 9th, and 10th indices. The values at each tap are taken and modulo-2 added together to generate the new first index in the code. This process can be seen in Function 1: Generating Gold Codes (gpsgen(ICs, taps)). This function takes in the initial conditions that are specified and the taps that will be used to generate the codes.

Problem 2:

Once the gold codes are generated, they initially have values that are either 0 or 1, a binary phase shift key will map each value of 1 to -1 and each value of 0 to +1. This will allow the calculation of a correlation between signals/codes later on. Function 2: Binary Phase Shift Keying (bpsk(G)) takes in any size array or matrix and does the mapping by finding each index that contains a 1 and converts it to a -1, this is done first so that the entire code will not all become 1's in the case that all zero values are converted first. Similarly, all the indices that contain a value of zero are set equal to +1.

Once this is done to G1 and G2, an auto-correlation between G1 and itself and a cross-correlation between G1 and G2 are then taken and plotted. The function that will be used is circcorr.m that was provided.

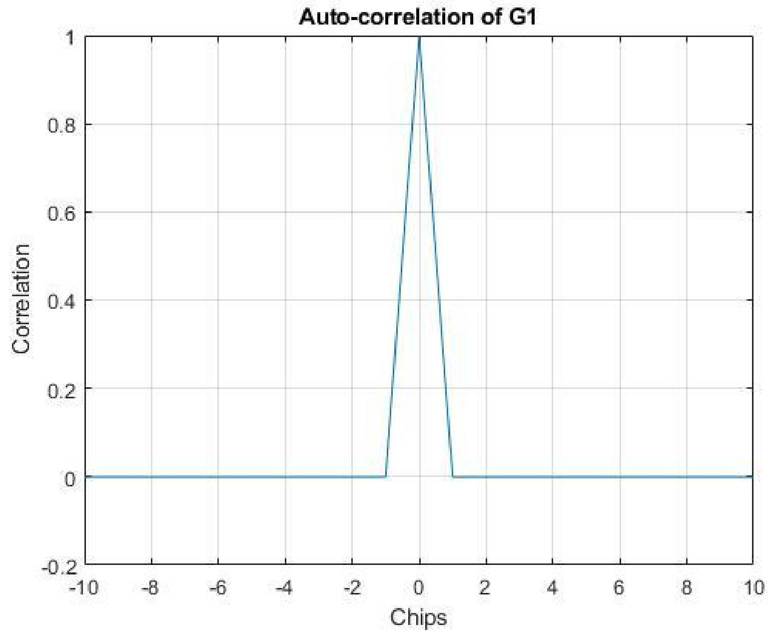

Figure 1 - The Auto-correlation of G1 Code

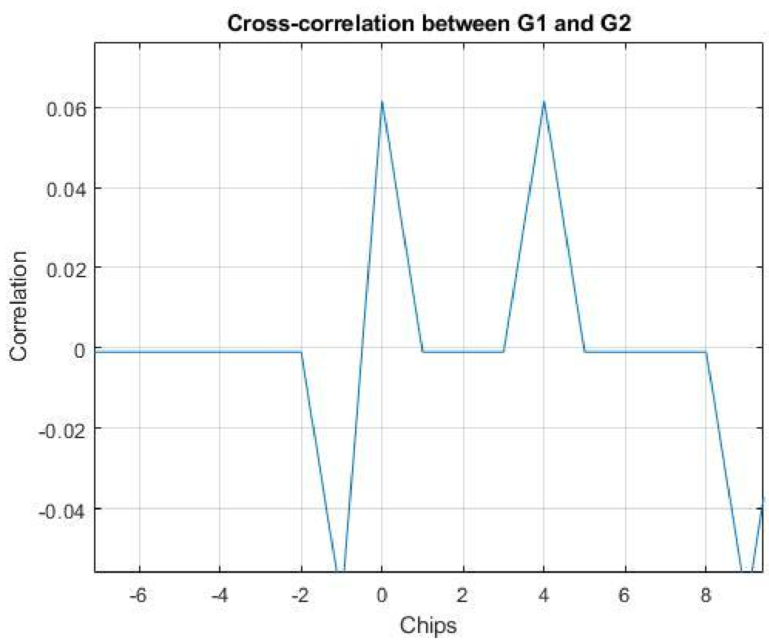

Figure 2 - The Cross-correlation between G1 and G2

The auto-correlation for G1 matches the theoretical plot exactly. This is shown in the shape of the plot, being flat at all points where the code does not line up with a value of -1/1023, and a peak that reaches up to 1 between -1 and 1 chips. For the cross-correlation between G1 and G2, the theoretical value for the correlation is to be -1/1023 (-9.7752e-04) for all γ. It can be seen in figure 2 that there are peaks at certain points that are near zero but not quite zero. This indicates that the two codes are not entirely unique and may have some portions that are similar, but since the correlation is very low (between -0.04 and 0.06) and the fact that the portions of the correlation where it is a flat line is equal to the theoretical values.

Problem 3:

To generate the PRN codes, a cycle and add code generator was used. This is seen in Function 3: Cycle Add Generator (cycleadd(G1,G2,prntaps)), which takes the two gold codes G1 and G2 and the taps that will be used on G2 to generate the PRN code. With PRN14, taps 7 and 8 will be used while taps 5 and 7 will be used to generate PRN25. The way this function works is similar to function 1, but this time there is no shifting needed. The PRN taps are taken and modulo-2 added together to create the G2 part of the code, this is then modulo-2 added to the G1 code to generate the final PRN code. These values were checked against the octal codes that were included in GPS-IS-200E and were confirmed to match up.

Problem 4:

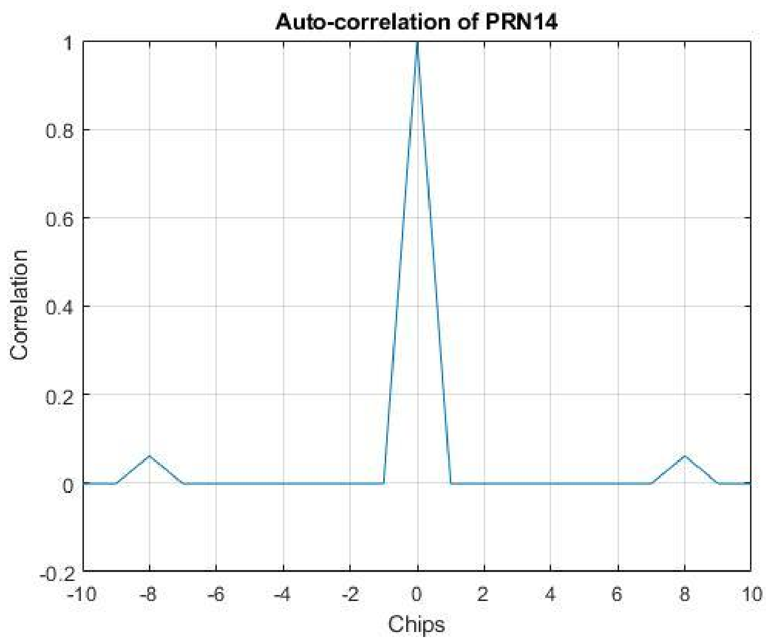

Figure 3 - The Auto-correlation of PRN14

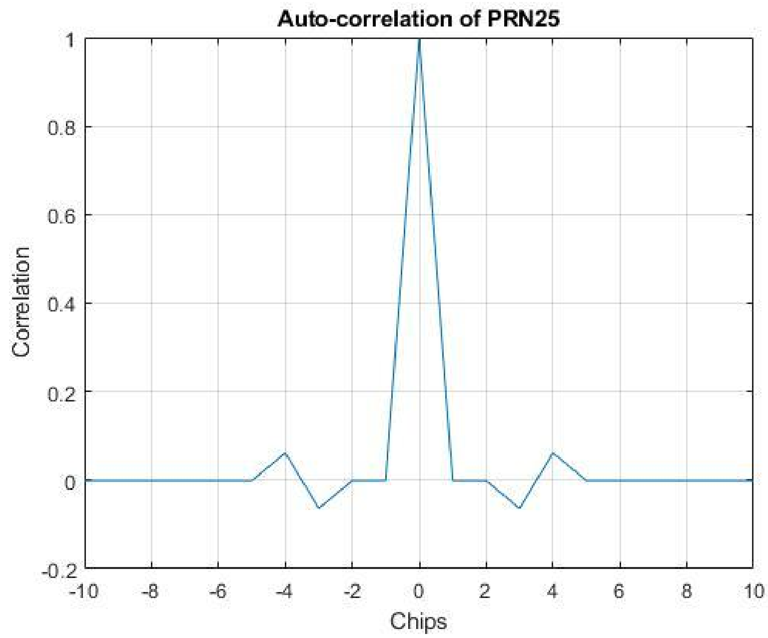

Figure 4 - The Auto-correlation of PRN25

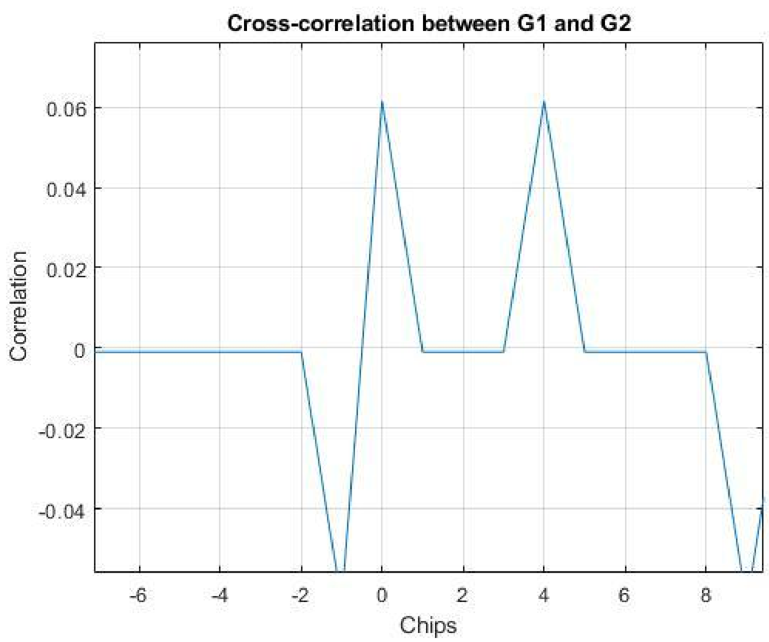

Figure 5 - The Cross-correlation Between PRN14 and PRN25

For the auto-correlations for PRN14 and PRN25, it can be seen that the plots resemble what is expected with slight variations. The overall structure of the correlation graph looks like it does in the auto-correlation for G1, but there are smaller peaks on either side of the central peak; these various other peaks are artifacts when applying the PRN algorithm. For both the PRN14 and PRN25, the central peak reached a maximum of 1 which is expected, and the flat parts of the correlation had a magnitude of -1/1023 which was also expected.

The cross-correlation between PRN14 and PRN25 also looked as expected. As explained for problem 2, the correlation between the two codes are nearly zero, with some peaks where there is slight similarity in the codes. These peaks are very small (in the same magnitude as shown in problem 2) and the flat parts of the graph are also the expected value of -1/1023.

In Misra and Enge, the peaks values for the correlation calculated on pages 365-367 are defined to be -1/1023, -65/1023, and 63/1023 when n is equal to 10. It can be seen and extracted from the graphs and calculations that these values match up. Viewing the correlation array for all of the correlation graphs, one can see that, in fact, the peaks are 0.06158 (63/1023), -0.06353 (-65/1023), and -0.000977517 (-1/1023). When the correlation graphs are plotted, these are the only values that are taken at each chip.