Appendix C

Method of Generating a New Auxiliary Signal

In Chapters 3 and 4, auxiliary signals were proposed for a VCC loop. The auxiliary signal $\alpha(t)$ was firstly proposed by Salih and Tantaratana. It makes the VCC loop update the phase difference of a received PN signal and a local PN signal to be zero as using the phase lock loop. The new auxiliary signal in Chapter 4 makes the VCC loop have 2 stable points at 0 and $NT_c/2$ which can reduce the acquisition time. In this appendix we describe a method for generating the new auxiliary signal.

Both auxiliary signals are generated from the idea of its auto-correlation which is a small triangle as shown in Figure C.1. The triangle covers only $2T_c$ from $-T_c$ to T_c which is not the whole period of the PN signal. So the auto-correlation of PN signal cannot use to control the phase updating of the phase alignment detector.

If we form a signal $g(t)$ as a summation of a PN signal $c(t)$ with the delay version $c(t-T_c)$, i.e.

$$g(t) = c(t) + c(t - T_c), \tag{B.1}$$

the cross-correlation of $c(t)$ with $g(t)$ is

$$R_{cg}(\beta) = \frac{1}{NT_c}\int_0^{NT_c} c(t+\beta)g(t)dt, \tag{B.2}$$

which is plotted in Figure C.2. We see that the cross-correlation is a trapezium which the base covers the area between $-2T_c$ to T_c. As this process we can expand the area of cross-correlation to cover the whole period of the PN signal.

As the analysis method in Chapters 3 and 4, the VCC loop discriminator characteristic is the product of the cross-correlation of $x(t)$ and $c(t)$ with the power of the received signal. When the input of the VCC is positive, the phase of the local PN signal is increased. When the input of the VCC is negative, the phase of the local PN signal is decreased. Then, we can design the number of stable points of the VCC loop by designing the cross-correlation $R_{cg}(\beta)$ to have the area of the positive equal to the area of negative. The stable points and unstable points are between positive and negative area of the cross-correlation of an auxiliary signal and a PN signal.

We must design the cross-correlation of an auxiliary signal to have positive area equal to negative area because we need to neglect the value $-1/N$. We see that when we form an auxiliary signal by adding delay or advance versions of a signal $c(t)$ the undesired value $-1/N$ will increase and also reduce the positive magnitude of the auto-correlation as show in Figure C.2.

We can maintain the magnitude of the auto-correlation by subtracting delay or advance versions of a signal $c(t)$ at the position of negative area that we want. The number of these subtracting must be equal to those of adding. By using this idea we can cancel the undesired value.

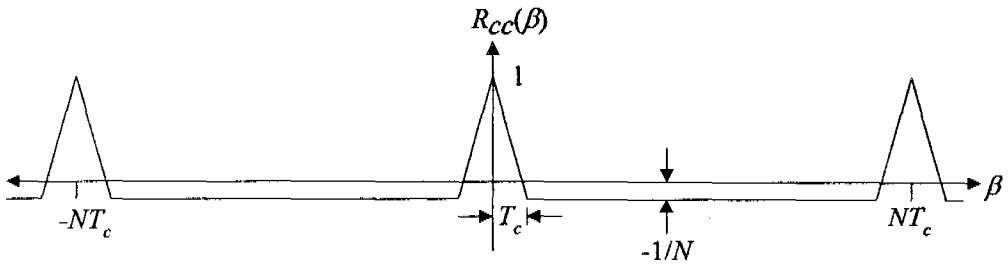

Figure C.1: The periodic auto-correlation function $R_{cc}(\beta)$.

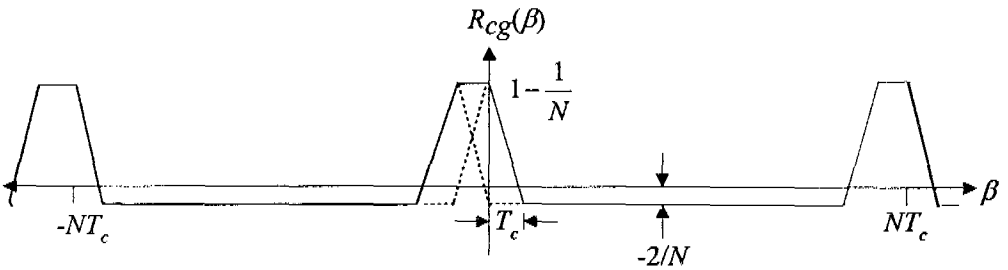

Figure C.2: The periodic cross-correlation function $R_{cg}(\beta)$.