Radio and Sampling Frequency Error Detection Algorithm for Extended Global Platform (XGP)

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Abstract

Extended Global Platform(XGP) is developed as high speed wireless mobile communication system in Japan. XGP tries to realize high speed and large capacity data communication as a result of adopting Orthogonal Frequency Division Multiple Access(OFDMA) technology. A common problem with OFDMA is Inter Carrier Interference caused by Radio and Sampling Frequency Error. This paper proposes a new Radio and Sampling Frequency Error detection algorithm for XGP. Simulations show that detectable range of Radio and Sampling Frequency Error. As a result, Radio Frequency Error is successfully detectable from -11[%] to +11[%] range, Sampling Frequency Error is also detectable from -1400[ppm] to +1400[ppm] range.

Keywords: Extended Global Platform(XGP), Orthogonal Frequency Division Multiple Access(OFDMA), Radio Frequency Error, Sampling Frequency Error

1 Introduction

Extended Global Platform(XGP) is targeting for an enhanced next-generation Personal Handy-phone Systems(PHS). XGP has adopted Time Division Duplex(TDD) and Time Division Multiple Access(TDMA), which is the same as the PHS. TDD is the application of time-division multiplexing to separate Uplink and Downlink. TDMA is a channel access method to divide time flame into plural time slots. The difference between XGP and PHS is the addition of Orthogonal Frequency Division Multiple Access(OFDMA) technology. A common problem with OFDMA is Inter Carrier Interference by Radio Frequency Error and Sampling Frequency Error. Radio Frequency Error is is caused by up-conversion and down-conversion frequency difference and Doppler effect. Sampling Frequency Error is a Sampling Interval error that is caused by the miss accuracy of system clock. This paper proposes a new Radio Frequency Error and Sampling Frequency Error detection algorithm for XGP.

2 Extended Global Platform

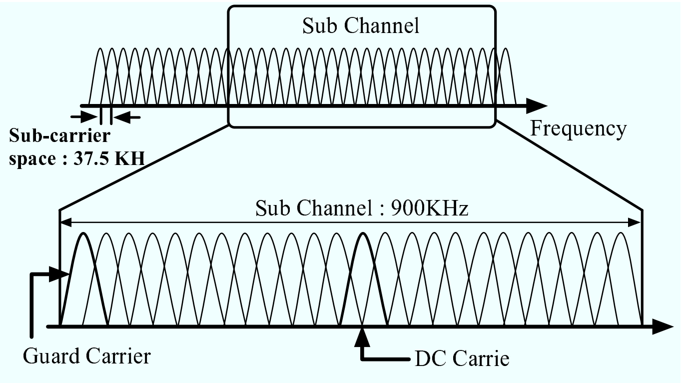
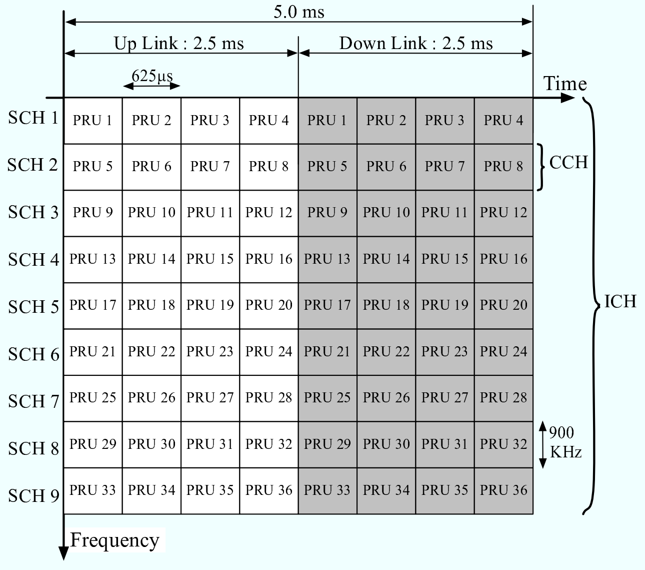


Fig 1: Subcarrier Spectrum of OFDMA system

Fig.1 shows a subcarrier spectrum of OFDMA system that is a multi-user version of Orthogonal frequency-division multiplexing (OFDM) digital modulation scheme. Multiple access is achieved in OFDMA by assigning a sub-channel ,which is a set of subcarriers, to individual users. The sub-channel is composed of 24 subcarriers. The first subcarrier(F1) is a Guard Carrier. It is not used for data transmission in order to prevent channel interference. The middle subcarrier(F13) is a DC carrier. It is not used for data transmission to disappear data when calculating the Discrete Fourier Transform(DFT).



	Up Link : 2.5 ms				Down Link : 2.5 ms			
SCH 1	PRU 1	PRU 2	PRU 3	PRU 4	PRU 1	PRU 2	PRU 3	PRU 4
SCH 2	PRU 5	PRU 6	PRU 7	PRU 8	PRU 5	PRU 6	PRU 7	PRU 8
SCH 3	PRU 9	PRU 10	PRU 11	PRU 12	PRU 9	PRU 10	PRU 11	PRU 12
SCH 4	PRU 13	PRU 14	PRU 15	PRU 16	PRU 13	PRU 14	PRU 15	PRU 16
SCH 5	PRU 17	PRU 18	PRU 19	PRU 20	PRU 17	PRU 18	PRU 19	PRU 20
SCH 6	PRU 21	PRU 22	PRU 23	PRU 24	PRU 21	PRU 22	PRU 23	PRU 24
SCH 7	PRU 25	PRU 26	PRU 27	PRU 28	PRU 25	PRU 26	PRU 27	PRU 28
SCH 8	PRU 29	PRU 30	PRU 31	PRU 32	PRU 29	PRU 30	PRU 31	PRU 32
SCH 9	PRU 33	PRU 34	PRU 35	PRU 36	PRU 33	PRU 34	PRU 35	PRU 36

Fig 2: Frame Structure

Fig.2 shows frame structure for XGP, in the case of Effective Channel Bandwidth 8.1MHz. In 5.0 ms frame duration, eight 625us TDMA slots are assigned. In frequency axis, total band width is divided into plural 900kHz sub-channels(SCH). One 625us TDMA slot and 900kHz SCH is called PRU(Physical Resource Unit). Any one of sub-channels can be used as Common Channel(CCH) for control communication. The others are used for Individual Channels(ICH) for individual data communication.

Fig.3 shows that the detail structure of one PRU of CCH and ICH. In the time-domain, there are 19 OFDM symbols. In the frequency domain, 24 subcarriers are used. CCH has more Pilot and Training symbols. While ICH is composed of more Data symbols.

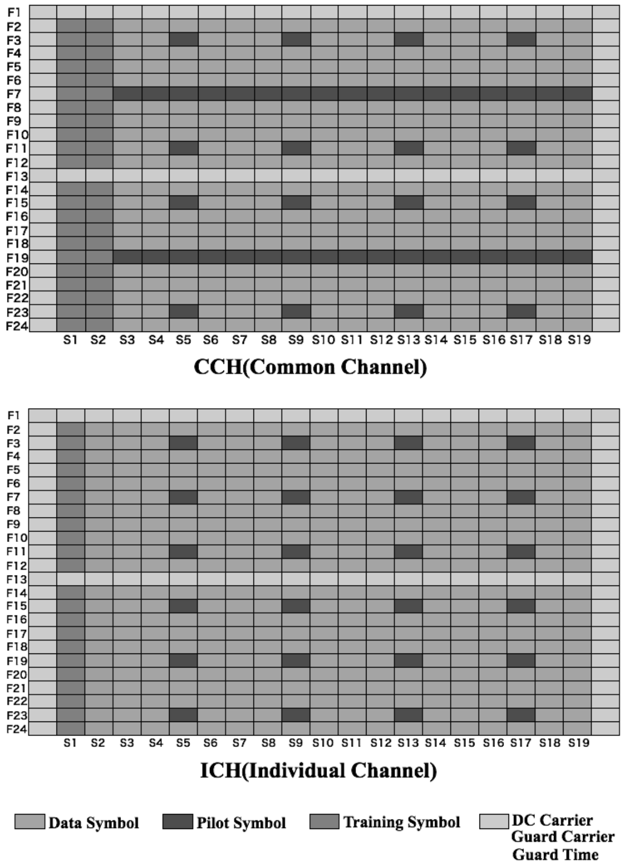


Fig 3: PRU

3 Detection Algorithm

The detection algorithm is based on the phase rotation of the pilot symbol in PRU as Fig.4. One PRU are composed of 24 subcarriers. F1 to F12 is considered as high frequency region and F13 to F24 as low frequency region. The rotation average of each high frequency and low frequency region is used to calculate both Radio and Sampling Frequency Error as equation (1).

$$LowAvg = \frac{p(F3,S5)^* \times p(F3,S9) + \ldots + p(F11,S13)^* \times p(F11,S17)}{9}$$
$$HighAvg = \frac{p(F15,S5)^* \times p(F15,S9) + \ldots + p(F23,S13)^* \times p(F23,S17)}{9} \quad (1)$$

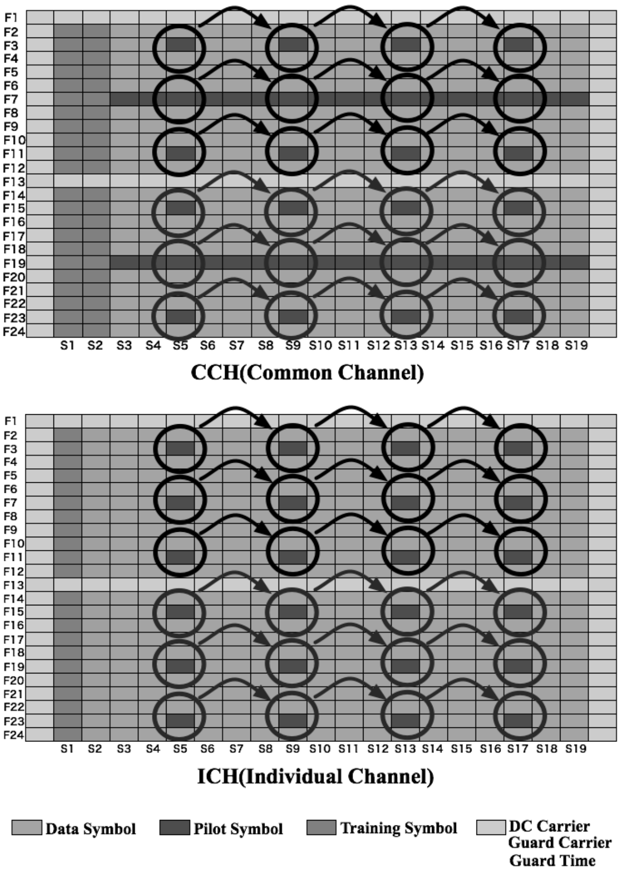


Fig 4: Rotation of the Pilot symbol

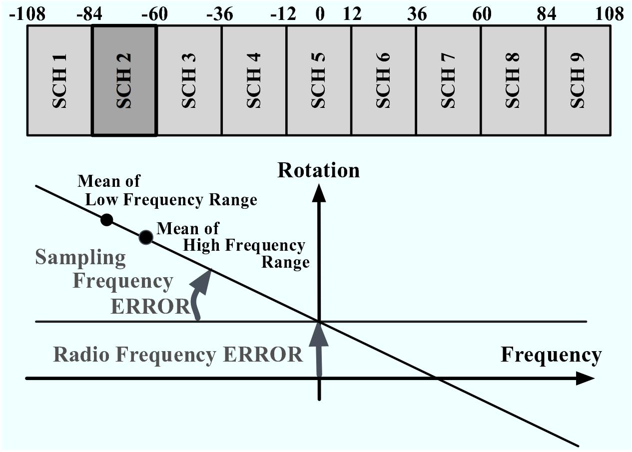


Fig 5: Rotation

Fig.5 shows a carrier index number of all SCHs with the center index as 0. Radio Frequency Error generates uniform pilot rotation in time domain for all index position. However, Sampling Frequency Error generate rotation which is proportional to the index number as show in Fig.5. The Radio Frequency Error can be obtained by the intercept. The Sampling Frequency Error can be obtained by the gradient. Using the average value obtained by equation (1), intercept and gradient can be calculated. Therefore, Radio and Sampling Frequency Error can be obtained.

3.1 Assuming

Radio Frequency Error and Sampling Frequency Error to and β individually and carrier number of low and carrier number high to n and m, average rotation of low and high frequency are obtained by equation (2).

$$\begin{aligned}
&LowAvg = Ae^{j2\pi(\;\; f)(1+\frac{1}{8})(1-\;\;)}\\
&= Ae^{j2\pi n(\frac{\Delta f}{nf_0})\frac{9}{8}(1-\;\;)}\\
&= Ae^{j\frac{9}{4}\pi n(\frac{\alpha}{n})(1-\;\;)} = Ae^{j\frac{9}{4}\pi n(\frac{\alpha}{n}-\;\;)}\\
&= Acos\frac{9}{4}\pi n(\frac{\alpha}{n}-\beta) + jAsin\frac{9}{4}\pi n(\frac{\alpha}{n}-\beta)\\
&HighAvg = Ae^{j2\pi(\;\; f)(1+\frac{1}{8})(1-\;\;)}\\
&= Ae^{j2\pi m(\frac{\Delta f}{mf_0})\frac{9}{8}(1-\;\;)}\\
&= Ae^{j\frac{9}{4}\pi m(\frac{\alpha}{m})(1-\;\;)} = Ae^{j\frac{9}{4}\pi m(\frac{\alpha}{m}-\;\;)}\\
&= Acos\frac{9}{4}\pi m(\frac{\alpha}{m}-\beta) + jAsin\frac{9}{4}\pi m(\frac{\alpha}{m}-\beta)
\end{aligned} \tag{2}$$

Each sum rotation is obtained with the use of each average value by equation (3).

$$\begin{aligned}
&tan\frac{9}{4}\pi n(\frac{\alpha}{n}-\beta) = \frac{imag(Low\;\;vg)}{real(Low\;\;vg)} = LowSum\\
&tan\frac{9}{4}\pi m(\frac{\alpha}{m}-\beta) = \frac{imag(High\;\;vg)}{real(High\;\;vg)} = HighSum
\end{aligned} \tag{3}$$

Equation(3) can be approximated as equation(4) when assuming the error is small value.

$$\begin{aligned}
&\frac{9}{4}\pi n(\frac{\;}{n}-\beta) = LowSum\\
&\frac{9}{4}\pi m(\frac{\;}{m}-\beta) = HighSum
\end{aligned} \tag{4}$$

Therefore, Radio Frequency Error( ) and Sampling Frequency Error(β) are obtained by equation (5).

$$\begin{aligned} &= \frac{m \cdot LowSum - n \cdot HighSum}{\frac{9}{4}\pi(m-n)} \\ \beta &= \frac{LowSum - HighSum}{\frac{9}{4}\pi(m-n)} \end{aligned} \qquad (5)$$

4 Computer Simulation

The proposed detection algorithm is verified by MATLAB simulation. Table.1 summarizes simulation conditions. Fig.6 and 7 show the simulation results. X axis of graph is error, Y axis of graph is detection error. Radio Frequency Error is successfully detectable from -11[%] to +11[%] range. Sampling Frequency Error is also detectable from -1400[ppm] to +1400[ppm] range by this proposed algorithm.

Table 1: Simulation Parameters

FFT size	512
Number of Subchannels	9
Used Subchannels	2 SCH
Sub-carrier space	37.5KHz
OFDM Symbol	33.33us(S1),30us(S2-S19)
Guard Interval	6.66us(S1),3.33us(S2-S19)
OFDM Data	26.67us

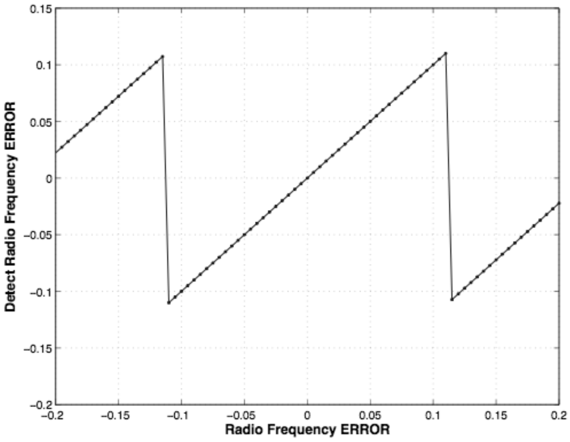


Fig 6: Radio Frequency Error Detection

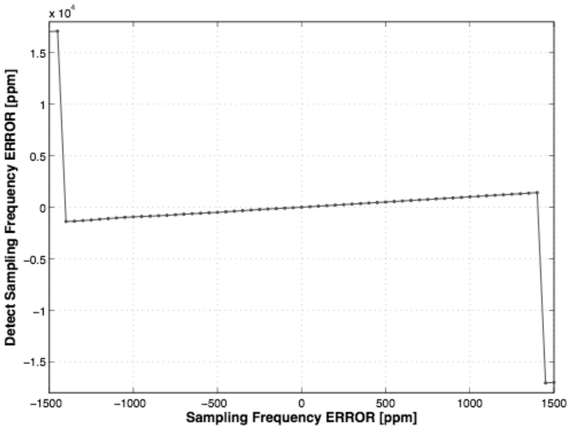


Fig 7: Sampling Frequency Error Detection

5 Conclusion

Radio and Sampling Frequency Error Detection algorithm is proposed for XGP. Using the proposed method, Radio Frequency Error is successfully detectable from -11[%] to +11[%] range, Sampling Frequency Error is also detectable from -1400[ppm] to +1400[ppm] range.

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