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Frequency Estimation Circuit Using Residue Number System

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We propose a circuit system to estimate high frequency signal using multiple low frequency sampling circuits. If high sampling frequency is used for frequency estimation, high frequency signals can be directly estimated. However handling of high frequency signals in electronic circuits is difficult, and hence the proposed circuit is relatively easy to implement.

Our proposed system is based on aliasing phenomena in frequency domain in waveform sampling and the residue number theory. Fig. 1 shows the proposed system, and a cosine wave with high frequency is provided as an input signal. Then cosine and sine signals with the same frequency are generated with an RC polyphase filter and they are fed into 3 sampling circuits with different (relatively prime) and low sampling frequencies. For their outputs, complex FFT are performed. Since the high frequency signal is sampled with low frequency clocks, the aliasing occurs. However, each aliased frequency different because each sampling clock frequency is different in 3 sampling circuits. Each aliased frequency corresponds to the residue number for each sampling clock frequency. Then according to the Chinese remainder theorem, the input frequency can be estimated.

Example: Supposed that the input frequency is 12 GHz, and the sampling frequencies are 229 kHz (fs1), 233 kHz (fs2), and 239 kHz (fs3). Also the frequency resolution is 1 kHz. Table 1 shows the residues for each sampling frequency. Fig. 2 shows simulation results of $f$res1, $f$res2, $f$res3 in Fig. 1. We can estimate the input frequency $f$in as 12GHz from Table 1.

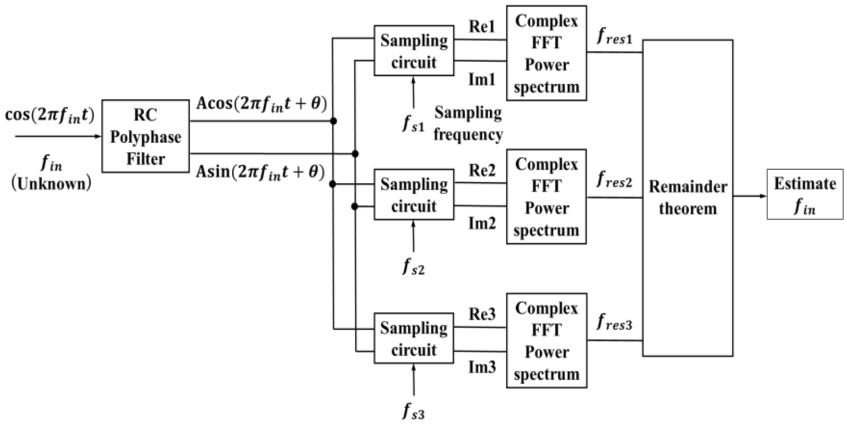

Fig.1 Proposed system

Table 1: Remainder Theorem

m1	m2	m3	k
0	0	0	0
1	1	1	1
2	2	2	2
⋮	⋮	⋮	⋮
90000	115000	48000	11998000
91000	116000	49000	11999000
92000	117000	50000	12000000
93000	118000	51000	12001000
94000	119000	52000	12002000
⋮	⋮	⋮	⋮
157321	170321	85321	12752321
157322	170322	85322	12752322
157323	170323	85323	12752323

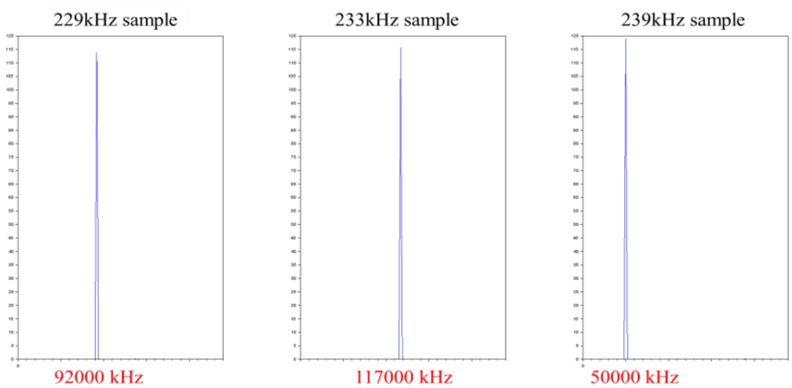

Fig. 2: Result of complex FFT

· Reference
[1] Yoshiro Tamura, Ryo Sekiyama, Koji Asami, Haruo Kobayashi, "RC Polyphase Filter As Complex Analog Hilbert Filter", IEEE 13th International Conference on Solid-State and Integrated Circuit Technology, Hangzhou (Oct. 2016).