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Graduate Institute of Communication Engineering, National Taiwan University

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In this issue

Technology Developed in GICE

A Wide-range 130-nm CMOS Statistic-based Frequency Ratio Calculator

from Electromagnetics Group

I. INTRODUCTION

The phase-locked loop (PLL) is an essential function block for frequency synthesizers and clock generation circuits. Digital PLLs have become popular for on-chip clock generation because of easy adaptation to different CMOS technology. Two major types of all-digital PLL (ADPLL) architectures have been developed in past few years to achieve both fine frequency resolution and low phase noise. The divider-based ADPLL utilizes the multi-modulus dividers and delta-sigma modulator to perform fractional-N signal division. The divided output signal is compared with the reference signal by a bang-bang phase frequency detector (BBPFD). Although the circuit implementation is comparatively simple, it usually takes longer time to settle. The counter-based ADPLL utilizes a counter and a time-to-digital converter (TDC) to obtain the information of frequency and phase differences between the output and reference signals. Excellent performance can be achieved with this kind of architecture, but sophisticated techniques and high performance TDCs are required [1]-[2].

The first frequency ratio calculator (FRC) is proposed as a simple but robust alternative function block to BBPFDs and TDCs in digital PLLs for fast locking. The FRC gives out both the integer and fraction of the frequency ratio between an input signal and a reference signal by statistical means. The frequency ratio calculation of FRC takes only two reference clocks and the outputs are in digital form. Compared to the conventional approaches, the time and power for performing equivalent fractional-frequency division on the oscillator signal are conserved. The 130-nm CMOS FRC

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GICE Honors

Prof. Yu-Chiang Frank Wang

GAN Project Competition
First Prize winner
MOST Workshop on
Generative Adversarial Networks

Prof. Tzong-Lin Wu

Editor in Chief for IEEE
Transactions on
Electromagnetic Compatibility

Message from the Director

Tzong-Lin Wu

Professor & GICE Director

The weather is getting warmer and lots of flowers bursting into full bloom in the NTU campus. GICE will continue to provide the best research environment and professional curriculums, never become conceited and never slackening our effort to strive for excellence on the dedication of teaching and research.

This issue is quite rich and informative; we invite Prof. Yi-Jan Emery Chen and Prof. Jian-Jiun Ding to share their recent research.

With the nurturing and the support from all GICE faculties, it's gratified to see the growth and the booming development of GICE.

Please have a cup of coffee or tea, and enjoy the reading of GICE Newsletter!

Technology

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operates on the input signal up to 850 MHz and achieves an accuracy of less than 0.01.

II. Frequency Ratio Calculator Design

Fig. 1 shows the block diagram of the FRC, which is composed of the integer and fractional counters. The reference signal goes through a line of 127 delay cells to generate 127 delayed reference signals. The counters are used to count the number of rising edges of the input signal within each reference signal period. The number of count is either N or N+1 assuming the frequency ratio of the input and reference signals falls between these two integers. N is determined by the selector to be the integer frequency ratio. The fractional frequency ratio is calculated by means of dividing the number of reference signals that count (N+1) rising edges by the overall number of reference signals (128 in our implementation). Since the counters take up a large amount of area, those for fractional frequency ratio calculation are replaced with 1-bit toggle logic circuits. The toggle logic sends out "1" for odd number count of rising edges of the input signal within its corresponding reference cycle. All the toggle logic outputs are summed together for ratio calculation. Fig. 2 illustrates the fractional ratio calculation. The period of the reference signal is larger than that of input signal by more than N times. Nevertheless, the delay, TD, of a single delay cell is much shorter than the period of input signal, TIN. The impulse symbols represent the rising edges of the waveforms.

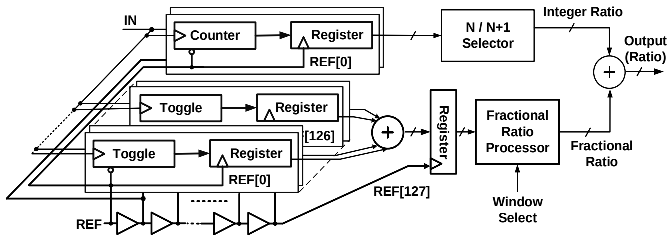

Fig 1. Block diagram of the proposed FRC.

The delayed reference signals whose delays are more than one input signal period can be equivalently shifted one or more input signal periods back and overlaid on the first input signal period as shown at the bottom of Fig. 2.

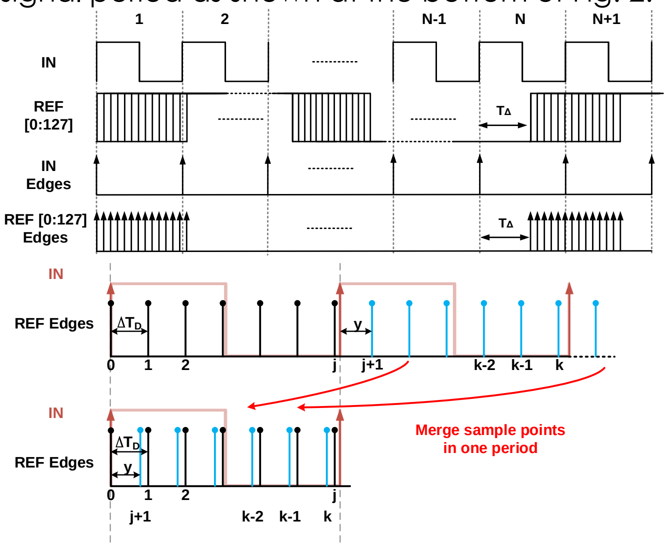

Fig 2. Illustration of fractional frequency ratio calculation.

In this way, the rising edges of the 128 reference signals are regarded as distributing evenly within the first input signal period. The positions of the rising edges of the reference signals correspond to the rising edge counts of the input signal. The fractional frequency ratio can be derived by (counts of N+1) / (number of references). With the design of 128 reference signals, the resolution of fractional frequency ratio is less than 0.01. The overall delay of the 127 delay cells is designed to be less than one reference cycle, and the ratio calculation can be finished within two reference cycles. Unlike TDCs that require strict control of the delays to ensure the

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performance, the variation of delay cell characteristics does not have significant impact on the accuracy of the FRC because little perturbation on the individual delay has little effect on the statistics of uniformly distributed samples of large number.

III. MEASUREMENT RESULT

The FRC is fabricated in 130 nm CMOS technology and its active area is 0.054 mm2. Operated at 1.2 V, the FRC draws 4.3 - 15.9 mA depending on the input signal frequency. The measurement of the FRC at the supply voltage from 1.0 V to 1.4 V with a step of 0.1 V is shown in Fig. 3. The input signal frequency ranges from 135 to 850 MHz. With more than 10% variation in supply voltage, the maximum measured error is less than 0.02. Six FRC chips were measured to check the characteristic variation and the measured error of fractional frequency ratio is less than 0.015. The chip microphotograph and measurement summary of the 130-nm CMOS FRC are shown in Fig. 4.

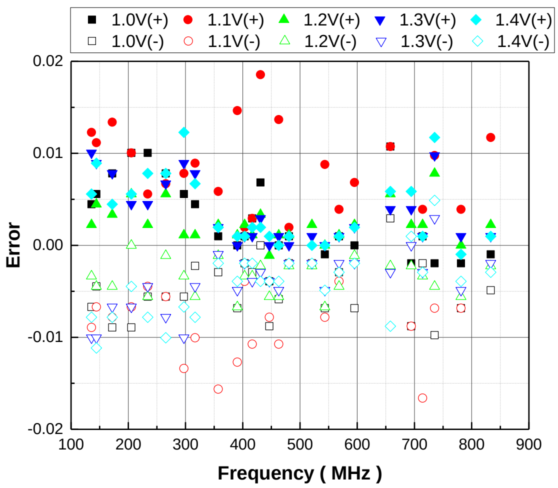
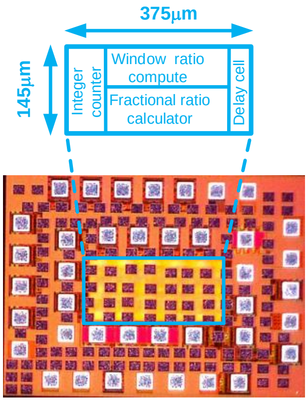


Fig. 3. The measured errors of decimal fractional frequency ratios for the supply from 1.0 to 1.4 V with a step of 0.1 V.



Parameter	This work
Technology	130nm CMOS
Supply voltage	1.2 V
Area	0.054 mm^2
Power	4.3 – 15.9 mW
Reference Freq.	40 MHz
Input Freq.	135 - 850 MHz
Ratio accuracy	< 0.01
Cal. Time	2 reference cycles (50ns)

Fig. 4. Chip microphotograph of the 130-nm CMOS FRC and its performance summary.

IV. CONCLUSION

The presented FRC is the first of its kind integrated-circuits capable of calculating the fractional frequency ratio of two signals. The integer and fractional ratios are represented by 5-bit and 10-bit digital outputs, respectively. The resolution of the fractional frequency ratio can be increased by adding more delay cells for the reference signal. Thanks to the statistic calculation mechanism, the FRC performance is resistant to PVT variation. In addition, the implementation of the FRC can be easily ported to another CMOS technology node because there is no critical analogy component in its circuit blocks. When used in digital PLLs, the FRC does not need the input signal down-converted fractionally to roughly the same frequency as the reference signal so it can simplify the PLL implementation and reduce the contribution of scaled reference phase noise. With the introduction of FRC, more function blocks of high-performance digital PLLs can be developed in digital design flow and it will shorten the design cycle and improve the design portability.

REFERENCES

[1] A. R. Ximenes, G. Vlachogiannakis, and R. B. Staszewski, “An ultracompact 9.4–14.8-GHz transformer-based fractional-N all-digital PLL in 40-nm CMOS,” IEEE Trans. Microw. Theory Tech., vol. 65, no.11, pp. 4241–4254, Nov. 2017.

[2] T. Jang, S. Jeong, D. Jeon, K. D. Choo, D. Sylvester and D. Blaauw, "A 2.5 ps 0.8-to-3.2 GHz bang-bang phase- and frequency-detector-based all-digital PLL with noise self-adjustment," ISSCC Dig. Tech. Papers, pp. 148-149, Feb. 2017.

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Technology

Frontalization for Deep Learning Based Facial Expression Recognition

from Communication and Signal Processing Group

I. INTRODUCTION

Facial expression recognition (FER) plays a critical role in people's life. Nowadays, Automatic FER is an important technique in human-computer interfaces and surveillance systems. The proposed work focuses on methods based on static images and it considers the seven basic expressions.

As described in [1], an automatic FER system consists of three steps: face acquisition, facial data extraction and representation, and facial expression recognition. After the face is detected, the facial features that are changed with expression need to be extracted. The changes are usually represented as geometric feature-based methods or appearance-based methods in some traditional works. Recently, a lot of methods using convolutional neural networks (CNN) for FER can also be found in the literature.

We proposed a CNN based system with face frontalization and the hierarchical architecture for FER, as shown in Fig.1. "Frontalization" is to map a rotated face to a frontal face. It can reduce data redundancy and improve the integrity and the input facial image.

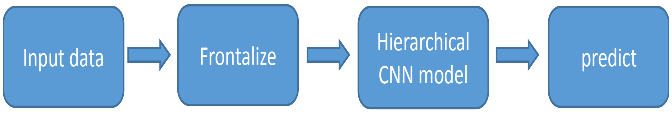

Fig.1 : The system diagram of the proposed FER architecture.

We begin by computing a 3×4 projection matrix. We find 2D-3D correspondences between the points in the input image and the points on the surface of our 3D face model. Given a textured 3D model of a face, the synthetic and rendered view of this model is produced by specifying a reference projection matrix $C_M = A_M\,[R_M\, t_M]$ where A_M is the intrinsic matrix and $[R_M\, t_M]$ is the extrinsic matrix consisting of a rotation matrix R_M and a translation vector t_M:

$$p' \sim C_M\, P \qquad (1)$$

Let $p' = (x, y)$ be the facial features detected in the 2D face model . From (1), we have the coordinates $P = (x, y, z)$ of the points on the surface of a 3D face model. With p' and P, the projection matrix can be estimated by using standard techniques.

Consequently, for every pixel coordinates $q' = (x', y')$ in the input image, we can use (2) to get the projection matrix C_Q between the input image and 3D face model.

$$q' \sim C_Q\, P \qquad (2)$$

We can back project all the pixels in the input image onto P with bicubic interpolation and use (1) to capture the pixels in the frontalized image.

A deep CNN consists of several feature extraction stages with alternating convolutional and pooling layers after the frontalization stage and is followed by fully-connected layers, which is treated as the recognition stage. To build diverse deep CNNs in the hierarchical model, we apply different training data sets and different classifiers for training. The effect of "different training data" is practiced by several preprocessing methods on the original data such as deformation and normalization. For the effect of "different classifiers", the Hierarchical model apply various random seeds for weight initialization and multiple hyperparameters.

As a result, the proposed system achieves ant accuracy of 70.65% on the frontalized data, surpassing the system over almost 3% without frontalization and the hierarchical structure.

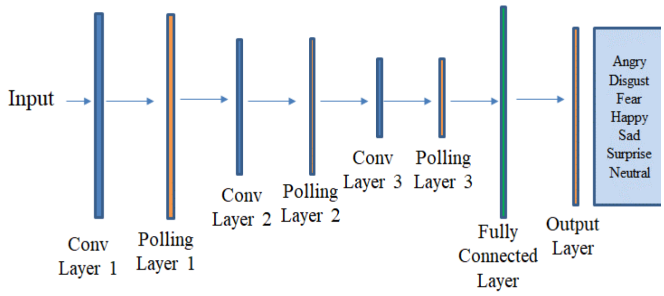

Fig.2 The deep CNN architecture for FER.

Reference

[1] S. Z. Li and A. K. Jain, Handbook of Face Recognition, Springer Science & Business Media, 2011.

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[2] A. T. Lopes, E. de Aguiar, and T. Oliveira-Santos. "A facial expression recognition system using convolutional networks," IEEE Conf. Graphics, Patterns and Images, pp. 273-280, 2015.

[3] Kim, Bo-Kyeong, et al. "Hierarchical committee of deep convolutional neural networks for robust facial expression recognition." Journal on Multimodal User Interfaces, vol. 10, pp. 173-189, 2016.

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Activities

GICE Delegates Visited Partner University for Students Recruitment

In 2014, NTU GICE (Graduate Institute of Communication Engineering) established a double degree program with the École nationale supérieure d'électronique, d'électrotechnique, d'informatique, d'hydraulique et des télécommunications (ENSEEIHT), a prestigious French engineering school in Toulouse. Soon in the summer of 2015, an M1 student of ENSEEIHT, Mr. Robin Jeanty, joined this double degree program under the supervision of Prof. Shih-Yuan Chen. One year later, another student, Mr. Mathis Zamboni, joined the program under the supervision of Prof. Chun-Ting Chou. Meanwhile, two senior graduate students of NTU GICE joined the double degree program and started their study at ENSEEIHT in September 2016. Since then, more schools in Europe have established double degree, exchange or internship programs with NTU GICE. In the summer of 2017, fourteen internship students from the University of Paris-Sud (Paris-Sud) visited NTU GICE. In September 2017, NTU GICE welcomed the first double degree student from Università degli Studi di Padova (University of Padova), the second-oldest university founded in 1222, and still one of the best in Italy. As of 2017, there were five double degree students, four exchange students and fourteen internship students from Europe studying at NTU GICE.

To further strengthen international collaboration and attract more students from Europe, NTU delegates visited École Nationale Supérieure de l'Électronique et de ses Applications (ENSEA), a graduate school of electrical engineering and computer science, located in Cergy close to Paris, University of Padova, ENSEEIHT and Paris-Sud in October 2017. The NTU delegates included Professor Tzong-Lin Wu, the Director of NTU GICE, Professor Huei Wang, the Associate Dean of the EECS College of NTU, and Professor Hsuan-Jung Su.

The introductory presentation given by NTU GICE Director Tzong-Lin Wu at ENSEEIHT.

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Activities

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On October 9th 2017, Professor Tzong-Lin Wu visited ENSEA and made a presentation to introduce NTU GICE and the double degree and internship programs to the students. He then discussed with professors of ENSEA, including Professor Thomas Tang, about collaboration between ENSEA and NTU and relevant issues.

On October 10th 2017, the NTU delegates visited the University of Padova. Professor Tzong-Lin Wu gave an introductory presentation of NTU and NTU GICE to the professors and students in the Department of Information Engineering. After the introduction, Professor Hsuan-Jung Su presented the research activities of the NTU GICE on Communications, Signal Processing, Data Science and Smart Networking. The research presentation was followed by the introduction to the double degree program made by Professor Tzong-Lin Wu and Professor Michele Zorzi (University of Padova). Over twenty students attended this event. Many of them showed interest in the double degree program and asked questions regarding courses, language, funding, etc. After the event, the NTU delegates had dinner with Professor Michele Zorzi, Professor Leonardo Badia, Professor Tomaso Erseghe and Professor Stefano Tomasin to further discuss the double degree program. On October 11th 2017, the NTU delegates visited the communication, networking, multimedia and electromagnetics laboratories of the Department of Information Engineering of the University of Padova to seek collaboration opportunities.

On October 12th 2017, the NTU delegates visited ENSEEIHT to meet the professors and students. The NTU delegates first met with the Heads of the Master and the International Office to assess the current status of the double degree and exchange programs. After that, the NTU delegates introduced the double degree and exchange programs to the students of Electronic Engineering, Electrical engineering, Computer Science, Telecommunication and Network. Following the introductory presentation made by Professor Tzong-Lin Wu, Professor Huei Wang provided an overview of NTU and NTU EECS, and Professor Hsuan-Jung Su presented the research activities at NTU GICE. Over twenty students attended the event, and many of them showed interest in joining the double degree program or conducting research internship at NTU GICE.

The presentation given by Professor Huei Wang, Associate Dean of the EECS College of NTU, at ENSEEIHT.

On October 16th 2017, the NTU delegates were invited to participate in the "International Day" of the engineering school of the University of Paris-Sud. Around 300 students attended this half-day event, which consists of two parts: oral presentation and country/university exhibition. In the first part of the event, an introductory presentation was given by Prof. Tzong-Lin Wu to provide an overview of the NTU EECS College, NTU GICE, and the double degree program to the students. In the second half, the NTU delegates set up a booth to explain the double degree program, exchange program, and the research internship to students who are interested in studying at NTU. This visit was a great success.

Discussion with ENSEEIHT students and professors.

Corner of student news

Lucien Bernard comes from France and he is pursuing Master Degree by joining double degree program via a collaboration agreement signed by NTUGICE and INPT-ENSEEIHT.

The engineering school, from which I come in Toulouse (INPT-ENSEEIHT), requires its students to have a stay abroad in order to achieve the complete and diversified training it provides. Considering the training opportunities for my last year, and having a personal attraction for Chinese culture, I made the choice to go to Taiwan.

Firstly, this double degree agreement, which has existed between the two universities for more than two years up to now, allows a few INPT-ENSEEIHT students to complete a double degree program in a university renowned in its field of electrical and computer science engineering. Following some feedbacks from the two previous students of this program, and having already been to mainland China twice, I did not hesitate for a second to seize this opportunity, simply wishing to discover a country speaking Mandarin Chinese, through the completion of my studies. And what a surprise it was when I landed on that island!

My stay in Taiwan started through an internship at NTU-GICE, to which I was able to register thanks to a research and practical training program, well-established by the Ministry of Science and Technology of Taiwan. During an orientation week mixing Taiwanese, French, Italian and Spanish people, I started to build some strong relationships with people from different backgrounds, with whom I could undertake to visit and discover Taiwan, during my weekends. I would particularly like to bear witness to the beauty of Taiwan's landscapes, of unparalleled beauty, whether they are the coastlines or the mountains, dotted by culture, various religions and indigenous peoples, whose meeting is highly recommend to you in order to open your mind.
Now, let me emphasize an important point about the Taiwanese people. They are a humble people, sometimes shy, sometimes naive, but once you get to know them, you realize that they live through it, and that is what characterizes them. They are finding pure happiness in their day to day life, very often on spontaneous occasions. One could say they are wearing their heart on their sleeve. Coming to Asia necessarily creates a culture shock for someone from Europe, but if that can reassure, Taiwanese people are very fond of French culture and its standards, which makes French one of the most learned foreign languages.

As for my studies, I joined a digital communications systems laboratory in order to develop my knowledge in the telecommunications part of signal processing, where I worked next to really enjoyable labmates, some of whom I shared common interests with. That is what led me to meet them outside the laboratory. Since I have a solid knowledge of Chinese, I was able to communicate easily with them, as well as to manage in good confidence my everyday life. My new challenge now is to learn their most widespread dialect, called Hokkien. Because yes, I fell in love with this country, for which I am sure to return.

Corner of student news

Alexandre Constantin comes from France and he is pursuing Master Degree by joining double degree program via a collaboration agreement signed by NTUGICE and INPT-ENSEEIHT.

I would like to share my new life in this article. Previously I was living in the countryside of France; I went to INP-ENSEEIHT engineering school in my first real big city in France: Toulouse, where I had to choose a specialization for my last year before getting my engineering degree. We had many opportunities: staying in INP-ENSEEIHT study one proposed field, go out of France as an exchange student or go in a dual-degree in prestigious universities. One of them was NTU, and with my interest on Asian culture, I started to learn Chinese: the agreement between NTU-GICE and my home engineering school was the opportunity to take. Now here I am, studying in NTU for one year and working in a laboratory specialized in Digital Image-Signal Processing.

My previous life explained, I will now present my impressions. When I took the plane to Taiwan I was an adventurer, the first one in my family to leave France for such long time and the first one to put a feet in that tropical island. My two first feeling was being uncomfortable in such crowded country compare to my village and how the weather can be that hot and humid. I also couldn't understand the written signs, I first met traditional characters.

The rush to get dormitory and to complete school registration finished I could finally rest and start to enjoy my Taiwanese life. Taiwanese people are mostly shy but very kind when you take time to speak with them, they helped you if you are lost, and they know how to respect other's belongings so it's really easy to merge into their culture. The food is also quite good, you can find many different meals for very small prices, so most of the people are not cooking, they just buy when they are hungry, and the dormitory doesn't have a real kitchen.

I spend most of my days working in my laboratory, I enjoy my time there, studying aerial images classification, I can speak to very smart Taiwanese students in that field and confront our ideas. I also discovered the East-Asia research area that was completely new for me. The courses are also interesting thanks to the professors who want us to bring creativity in our homeworks, even if there are more individual works compare to France. Since it's my first time in a big university (so big that I'm using a biking to move in the daily life), it's interesting to learn differently: just courses and you practice and make homeworks by yourself. I can also learn intensively Chinese and train it every day, I can now read my Chinese menu to order food and understand basic conversations.

To conclude my life in Taiwan is far more better than the first days, I miss cooking my cake every Sunday for the week's energy, drinking good coffee and also eating French patisseries, but I'll never regret that experience and I have learnt a lot about myself and meet very interesting international students. I also have enjoyed the Taiwanese landscapes (sea shores, mountains) and temples that cannot be found in France.

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