Northwestern | THE GRADUATE SCHOOL

Application for Admission

App Type **New Student**

Submitted Date **10-09-2018**

App ID# **78317135**

Intended Status **Full-time**

Entry Quarter **Fall 2019**

Prior TGS Applicant (Program)

Last Name **Liao**

First **I-No**

Middle

Gender Pronouns (US only)

Birthdate **01-30-1990**

Gender **Male**

Program **Computer Science: MS**

Specialization/Area of Interest **Artificial Intelligence and Machine Learning**

Cluster

Secondary PhD (MEAS Only)

MS Consideration (MEAS Only)

JD/PhD **No**

DPT/PhD **No**

Fee Waiver

US Vet/Active Forces

Ethnicity **Asian**

Hispanic **No**

Citizenship **TAIWAN**

Visa

Citizenship Status **International Student**

Country of Birth **TAIWAN**

Green Card #

Current Address

3F., No. 29, Sec. 2, Wenxing Rd.

Zhubei City, 302
TAIWAN

Permanent Address

3F., No. 29, Sec. 2, Wenxing Rd.

Zhubei City, 302
TAIWAN

Current Phone **+886-3-668-5228**

Cell Phone **+886-938-725-130**

Email Address **ino.liao@gmail.com**

Permanent Phone **+886-3-668-5228**

Preferred Phone Number **Cell Phone Number**

Previous Institution	From	To	Field of Study	Level	Degree	Date
National Chiao Tung University-College	09-01-2008	06-30-2012	Electronics Engineering		International Undergraduate Degree	06-30-2012
National Chiao Tung University-College	09-01-2012	09-30-2014	Electronics Engineering		International Graduate Degree	09-30-2014
Chalmers tekniska hogskola Goteborg	01-16-2012	05-29-2012	Exchange Student Program		International Non-Degree coursework	

Cumulative UG GPA		UG Junior/Senior Year GPA	
Cumulative UG GPA - Unconverted	**88.72**	Max UG GPA Scale	**100**
Cumulative Grad GPA			
Cumulative Grad GPA - Unconverted	**94.22**	Max Grad GPA Scale	**100**

Letters of Recommendation

1. **Wen-Chih Peng** **wcpeng@cs.nctu.edu.tw**
2. **Yu-Tai Ching** **ytc@cs.nctu.edu.tw**
3. **Hsin-Hung Chen** **hsinhung.chen@mediatek.com**
4.
5.

Are you interested in studying with specific faculty members? (List names below)

1. First Name **Ian** Last Name **Horswill**
2. First Name **Larry** Last Name **Birnbaum**
3. First Name Last Name
4. First Name Last Name

Please indicate the highest level of education completed by your parent(s) or guardian(s) (the one or two people most responsible for raising you)

First individual's highest level of education completed: **Graduate or professional degree**

If other, please explain:

Second individual's highest level of education completed: **Bachelor's degree or equivalent**

If other, please explain:

Language	Reading	Writing	Speaking

Self-Reported Test Scores

GRE Gen	02-23-2018	Verbal	153	61	Quant	168	94	A.W.	3.0	17	
GRE Sub								LSAT			
TOEFL	08-26-2017	Ovr	103	Read	28	List	27	Speak	23	Writ	25
IELTS		Ovr									
GMAT		Tot			Verb			Quant			A.W.			I.R.		
MCAT		Bioscience			Verbal			Physical Science		

Please list any honors you have been awarded

Have you applied for or been awarded an external fellowship?

Yes ○ No ⊗ If yes, please specify;

Please describe your plans for the future.

My aspiration is to become a software engineer who makes contributions to technology and solves real-world problems. Based on the current technology trend, the mobile phone is a necessity of every modern human being and it makes significant impacts of how people live. To fulfill my aspiration of improving human lives with technology, I am devoted to advancing the mobile phone industry with my specialties in CS.

MSCS program at Northwestern University fulfills my needs in both short-term and long-term goals. My immediate objective of my master's study is to equip myself with extraordinary CS competence so that I can combine it with my previous work experience in the industry. Through the rigorous courses in your well-structured program, I could acquire a comprehensive knowledge of computer science and build implementing capacity through projects. In this way, I can contribute my creativities to the industry right after my graduation.

Other Universities Applied (in preferred rank order)

1. School Drop Down	**Columbia University**	5. School "other"	
2. School Drop Down	**University of Wisconsin-Madison**	6. School "other"	
3. School Drop Down	**University of Southern California**	7. School "other"	
4. School Drop Down	**University of California-Irvine**	8. School "other"	
	New York University		

Academic misconduct? Yes ○ No ⊗ Convicted of crime? Yes ○ No ⊗

If answered yes, applicant is asked to upload explanation. If uploaded, explanation will be attached to end of application PDF.

I-No Liao
78317135

>> What are your professional plans following the completion of your graduate study? (Cont.)

Your program can also help me accomplish my long-term goal - become an influential engineer who creates revolutionary products through teamwork. Your program not only allows me to completely stimulate my potential but also creates opportunities for me to work with talented peers. By accomplishing collaborative course projects or personally conducting small group projects, I can gain experience in running sophisticated and large projects. Through cooperation, I can not only learn valuable insights from others but also sharpen my teamwork capability. I believe great teamwork makes everything possible and your program provides such environment for me to cultivate such competence.

Statement of Purpose

Over the course of my learning and work experience in the field of electronics engineering, my interest in studying computer science only grows stronger. Previously working as an RF system design engineer, I see the power of CS to provide effective solutions to break hardware limitation and to optimize the overall system performance. Fascinated by the power of algorithm and programming, I am determined to become an influential software engineer and make my contributions to advance technology. To reach my goal, I am applying to the M.S. CS Program at Northwestern University to develop my specialty in computer science.

I have built a strong foundation in CS as a major in Electronics Engineering (EE) at National Chiao Tung University (NCTU) by taking CS-related courses such as Computer Programming (I) and (II) (C/C++ programming), Data Structures, Computer Organization, Probability and Statistics, and Linear Algebra. I excelled both the requirements of my EE major and CS-related courses, earning a competitive overall GPA of 88.72/100. My interest in CS was further ignited when attempting to solve circuit optimization problems through programming during my master's study in EE at NCTU. I joined Professor Yu-Jiu Wang's RFVLSI Lab and researched 60-GHz Rectifier designs. To overcome intricate design trade-offs, I proposed Circuit Design Optimizer (CDO) to optimize circuit parameters by utilizing powerful optimization algorithms. CDO not only solved complex circuit design trade-offs but increased IC designers' work efficiency by helping them set optimal parameters. With the aid of CDO, I designed state-of-the-art RF Rectifiers and published the results in *IEEE Transactions on Microwave Theory and Techniques* and *IEEE Microwave and Wireless Components Letters*. The successful publications encouraged me to learn more about how software can solve real-world problems and make real impacts on the technology field.

After completing my Master's in EE, I continued to explore the possibilities of combining chip design with smart algorithms at MediaTek Inc. as an RF system engineer. Under the supervision of Dr. Hsin-Hung Chen, I was responsible for developing the Digital Pre-Distortion (DPD) algorithm that greatly reduced the power consumption of 4G-LTE (Long-Term Evolution) transceivers by linearizing RF amplifiers. The first generation DPD reduced 15% power consumption and successfully entered mass production. Furthermore, by introducing the ideas of fast-converging algorithms and memory polynomial approximation, I proposed the low-cost On-The-Fly Memory-Lite-DPD (OTF-MLDPD) which could not only adaptively update pre-distortion coefficients to overcome environmental changes but increase the DPD-applicable signal bandwidth by 10 times. OTF-MLDPD earned me MediaTek Inc. VAwards, one U.S. patent, and the opportunity to demonstrate the achievements to CTO and CEO at the year-end in-house CTO-exhibition.

With the success of the first generation DPD, I attempted to apply Machine Learning techniques to develop its later version. If DPD coefficient generator could be modeled by a deep neural network trained by supervised learning with training data collected from field trials, suitable coefficients could be generated instantly without the converging process. To realize the idea, I attended Machine Learning related seminars held by my company and online courses instructed by Professor Hsuan-Tien Lin at National Taiwan University in my spare time. However, I soon found that systematic learning is necessary for me to build full CS competence to solve challenging questions. Only through the regular courses in a well-structured program, I could acquire a comprehensive knowledge of a specific CS field, familiarize myself with advanced techniques, and build my implementing capacity through

projects. After thorough considerations, I decided to leave my job and devote myself to CS study.

To strengthen my qualification of graduate study in CS, I took “Algorithms” at NCTU and scored 99/100. For deepening my understanding, I spontaneously implemented all the algorithms covered in the course by C++. Moreover, to explore the areas of Data Mining and Machine Learning, I took “Data Mining” at NCTU and scored 96/100. My final project focused on NBA game winning prediction. The prediction accuracy reached 76.8% by applying composite 2-stage stacking model, consisting of SVM, GBDT, XGBoost, and AdaBoost.

In addition to learning from courses, I joined Professor Wen-Chih Peng’s Advanced Database System Laboratory at NCTU as a research assistant, focusing on badminton strategy analysis. I adopted the deep convolutional neural network to track trajectories of badminton in videos and achieved a precision of 86%. By analyzing the recorded trajectories using Data Mining skills, strategies were suggested for the player to win a game. During the research, pragmatically exploiting powerful deep neural networks and applying Data Mining algorithms to solve problems not only gained me more insights but brought me great pleasure and intention to deepen my knowledge in the related studies.

The objectives of my master’s study in CS is to cultivate strong skill sets, especially in the field of Data Mining and Machine Learning. I believe that the renowned M.S. CS Program at Northwestern University is my best choice. It provides a variety of courses that are essential for me to build solid foundations and develop specialized skills. The course “EECS 457: Advanced Algorithms” will advance my problem-solving capacity by applying suitable data structures and efficient algorithms. “EECS 495: Introduction to Database Systems” will instruct me to learn advanced databases to accomplish diverse data management applications, including data mining. Moreover, I am extremely interested in “EECS 395, 495: Optimization Techniques for Machine Learning and Deep Learning”, “EECS 469: Machine Learning and Artificial Intelligence for Robotics”, and “EECS 432: Advanced Computer Vision”, all of which will help me delve deeper into AI-related techniques and applications.

My goal after graduation is to become a resourceful software engineer who advances human life by solving real-world problems. Your prestigious program will provide me the opportunity to fulfill my aspiration. With my interdisciplinary background, work experience in the industry, and a strong curiosity about computer science, I am confident I would be an ideal candidate for your program. Thank you for your kind consideration.

國立交通大學
National Chiao Tung University

TRANSCRIPT OF ACADEMIC RECORD

Student No.:9711079 Date Enrolled:September 2008 電子工程學系學士班

Name:LIAO, I-NO(廖以諾) Date of Birth:January 30, 1990 Gender:M

Degree:B.S. in Electronics Engineering Graduation Date:June 2012

Subject	1st Semester Credit	1st Semester Grade	2nd Semester Credit	2nd Semester Grade
ACADEMIC YEAR (2008-2009)				
Calculus (I)	4.00	99		
Computer Programming(I)	3.00	89		
General Physics (I)	3.00	88		
Physics Laboratory (I)	1.00	82		
Electronics & Life	0.00	92		
Chemistry (I)	3.00	89		
Arts Appreciation Education(I)	0.00	P		
English Listening	2.00	89		
Physical Education	0.00	80		
Minitary Training	2.00	85		
Engineering Mathematics:Linear Algebra#	3.00	81		
Contemporary World: Transnational Social and Economic Issues#	2.00	78		
Calculus (II)			4.00	90
General Physics (II)			3.00	90
Logic Design			3.00	92
Probability and Statistics			3.00	88
Digital Laboratory			2.00	81
Physics Laboratory (II)			1.00	91
Service Learning I			0.00	P
Computer Programming(II)			3.00	87
Logic and Thinking			2.00	78
Arts Appreciation Education(II)			0.00	P
English Conversation#			2.00	84
Physical Education			0.00	80
Military Training			2.00	84
Credits earned / Average	23.00	87.96	25.00	87.04
Credits taken	23.00		25.00	
ACADEMIC YEAR (2009-2010)				
Differential Equations#	3.00	91		
Electronics (I)	3.00	91		
Introduction to Circuit Theory	3.00	91		
Electronics Laboratory (I)	2.00	87		
Service Learning II	0.00	P		
Data Structures	3.00	78		
Introduction to Materials Science	3.00	93		
Introduction to Art	2.00	86		
Introduction to Economics	2.00	86		
Physical Education	0.00	75		
Complex Variables			3.00	96
Electronics (II)			3.00	94
Electronics Laboratory (II)			2.00	84
Digital Circuits and Systems			3.00	98
Introduction to Modern Physics			3.00	97
Signals and Systems			3.00	86
The Taiwan History			2.00	91
Advanced English Listening			2.00	88
Physical Education			0.00	86
Military Training			2.00	90
Credits earned / Average	21.00	88.10	23.00	92.13
Credits taken	21.00		23.00	
ACADEMIC YEAR (2010-2011)				
Electromagnetics (I)	3.00	96		
Introduction to VLSI Design	3.00	88		
Introduction to Quantum Mechanics	3.00	88		
Semiconductor Device Physics	3.00	95		
Economic Laws	2.00	79		
Exploring English through-Movies	2.00	92		
Physical Education	0.00	87		
Viewing Einstein from the perspective of General Education	2.00	96		
Electromagnetics (II)			3.00	96
Seminar on Electronic Engineering (I)			0.00	89
Digital Signal Processing			3.00	77
Introduction to Microwave Engineering			3.00	98
Semiconductor Laboratory			2.00	97
Internet and Society			2.00	84
Physical Education			0.00	88
Special Project on Electronic Engineering (I)			0.00	87
Introduction to Laboratory Safety and Health			2.00	86
Credits earned / Average	18.00	90.83	15.00	89.80
Credits taken	18.00		15.00	
ACADEMIC YEAR (2011-2012)				
Computer Organization	3.00	85		
Modern Biology (I)	3.00	81		
Multimemedia English	2.00	94		
Digital Integrated Circuits	3.00	92		
Special Project on Electronic Engineering (III)	3.00	91		
Special Topics of Finance and Economics (I)	3.00	92		
Special Project on Electronic Engineering (II)	0.00	92		
The History of Western Classical Music	2.00	89		
Fundamentals of Photonics§			3.00	80
Antenna Engineering§			2.00	*F
Radar Systems and Applications§			2.00	*F
Remote Sensing§			2.00	70
Credits earned / Average	19.00	88.89	5.00	76.00
Credits taken	19.00		9.00	
Total credits:149.00				
Graduate score:88.72				

Grade remark:*: Fail, P: Pass, F: Fail, W: Withdraw, TR: Transfer Credit, #: Taught in English, §: Study at overseas universities

This transcript is certified as correct according to the record of the University.

Graduate Score: The average of thesis and coursework

90 or more=A+, 85 to 89=A, 80 to 84=A-, 77 to 79=B+, 73 to 76=B, 70 to 72=B-
67 to 69=C+, 63 to 66=C, 60 to 62=C-, 50 to 59=D, 1 to 49=E, 0=X

For undergraduate 60 is the passing score. For graduate 70 is the passing score.

http://www.nctu.edu.tw , E-Mail:registra@cc.nctu.edu.tw:

July 30, 2018

Registrar: I-Chi Chuang

國立交通大學

National Chiao Tung University

TRANSCRIPT OF ACADEMIC RECORD

Student No.:0150193 Date Enrolled:September 2012 電子研究所碩士班

Name:LIAO, I-NO(廖以諾) Date of Birth:January 30, 1990 Gender:M

Degree:M.S. in Electronics Engineering and Electronics Graduation Date:September 2014

Subject	1st Semester Credit	1st Semester Grade	2nd Semester Credit	2nd Semester Grade	Subject	1st Semester Credit	1st Semester Grade	2nd Semester Credit	2nd Semester Grade
The following subjects are accredited:									
Digital Integrated Circuits	3.00	TR							
ACADEMIC YEAR (2012-2013)									
Graduate Research	1.00	P							
Analog Integrated Circuits	3.00	91							
Digital Communication	3.00	92							
Seminar on Electronics-Circuits and Systems	0.00	85							
Introduction to Smart Sensing System Design	3.00	95							
Special topic on ESD Protection Design in CMOS Ics	3.00	88							
Graduate Research			1.00	P					
Microwave Circuits			3.00	90					
Radio-Frequency VLSI Design#			3.00	96					
Wireless Power Transmission System#			3.00	88					
Seminar on Electronics-Circuits and Systems			0.00	86					
Credits earned / Average	13.00	91.50	10.00	91.33					
Credits taken	13.00		10.00						
ACADEMIC YEAR (2013-2014)									
Graduate Research	1.00	P							
Graduate Research			1.00	P					
Credits earned / Average	1.00	----	1.00	----					
Credits taken	1.00		1.00						
ACADEMIC YEAR (2014-2015)									
Credits earned / Average	0.00	----							
Credits taken	0.00								

Total credits:28.00
Coursework average:91.43
Thesis: 97
Graduate score:94.22

Grade remark:*: Fail, P: Pass, F: Fail, W: Withdraw, TR: Transfer Credit, #: Taught in English, §: Study at overseas universities

July 30, 2018

This transcript is certified as correct according to the record of the University.

Graduate Score: The average of thesis and coursework Registrar:

90 or more=A+, 85 to 89=A, 80 to 84=A-, 77 to 79=B+, 73 to 76=B, 70 to 72=B-
67 to 69=C+, 63 to 66=C, 60 to 62=C-, 50 to 59=D, 1 to 49=E, 0=X

For undergraduate 60 is the passing score. For graduate 70 is the passing score.

http://www.nctu.edu.tw , E-Mail:registra@cc.nctu.edu.tw:

I-Chi Chuang

CHALMERS

Certificate of Registration

I-No Liao
19900130-T531

2018-07-02

Registered on		**Scope per period**	
KONV-002F0	**Bilateral Exchange Agreements-National Chiao Tung University (TW)**	**hp**	**2012-01-16 - 2012-05-29**
MCC045	Fundamentals of photonics 7.5 hp	7.5 hp	2012-01-16 - 2012-05-29
RRY055	Microwave and optical remote sensing 7.5 hp	7.5 hp	2012-01-16 - 2012-05-29
SSY100	Antenna engineering 7.5 hp	7.5 hp	2012-01-16 - 2012-05-29
RRY080	Radar systems and applications 7.5 hp	7.5 hp	2012-01-16 - 2012-05-29

60 credits (hp) represent a full academic year.

The above is an excerpt from the register of student records.

CHALMERS
UNIVERSITY OF TECHNOLOGY
Student and Education Office
Gothenburg, Sweden

CHALMERS

Official Transcript of Records

I-No Liao
19900130-T531

2018-07-02

Completed courses		Scope	Grade	Date	Note
MCC045	**Fundamentals of photonics**	7.5 hp	4	2012-03-05	1
0107	Examination	(7.5 hp)	4	2012-03-05	1
RRY055	**Microwave and optical remote sensing**	7.5 hp	3	2012-03-09	1
0107	Examination	(7.5 hp)	3	2012-03-09	1

60 credits (hp) represent a full academic year.

Notes
1 Grading scale: Five (5), Four (4), Three (3)

The above is an excerpt from the register of student records.

CHALMERS
UNIVERSITY OF TECHNOLOGY
Student and Education Office
Gothenburg, Sweden

I-No Liao

Email : ino.liao@gmail.com
Phone : +886-938-725-130

INTERESTS

Machine Learning, Data Mining, and Computer Vision

EDUCATION

National Chiao Tung University Hsinchu, Taiwan
Master of Science in Electronics Engineering; GPA: 94.22/100 (4.25/4.3) *Sept. 2012 – Sept. 2014*

- **Thesis:** A Millimeter-Wave RFID Passive Tag IC Using In-Phase Gate-Boosting Rectifier
- **Advisor:** Prof. Yu-Jiu Wang

National Chiao Tung University Hsinchu, Taiwan
Bachelor of Science in Electronics Engineering; GPA: 88.72/100 (4.03/4.3) *Sept. 2008 – June 2012*

- **CS-related coursework:** Computer Programming (I) and (II), Linear Algebra, Probability and Statistics, Data Structures, Algorithms, Data Mining, Computer Organization

SKILLS

Languages C/C++, Python, Matlab, Cadence Skill Code
Framework/Tools TensorFlow, Keras, Scikit-learn, OpenCV, Django, NumPy, Pandas, Git

EXPERIENCE

Advanced Database System Lab, National Chiao Tung University Hsinchu, Taiwan
Research Assistant (Advisor: Prof. Wen-Chih Peng) *Aug. 2018 – Present*

- Badminton Strategy Analysis Project
  - Achieved 86% badminton image tracking precision in videos by CNN-based deep learning model.
  - Built a database to store badminton trajectories and stroke types for the purpose of Data Mining.
  - Developed a game strategy recommender system based on classification.
  - Mentored 4 undergraduate students to learn Deep Learning and Data Mining techniques.

MediaTek Inc. Hsinchu, Taiwan
RF System Design Engineer *Dec. 2014 – Dec. 2017*

- Digital Pre-Distortion (DPD) Algorithm Design for 4G-LTE and 5G-NR Mobile Phone Applications
  - Achieved 15% power reduction on Power Amplifier by DPD.
  - Reduced 50% DPD hardware area by using interpolation to reduce the size of look-up tables.
  - Reduced 80% calibration time by applying an adaptive mechanism to skip pre-calibration.
  - Published one US patent regarding the adaptive pre-distortion mechanism.
- Automatic MLDPD Verification Platform Development
  - Developed a Matlab-based automatic verification API to verify MLDPD on smartphones.
  - Established an object-oriented MLDPD simulation framework to speed up algorithm development.
  - Increased 80% verification and simulation speed by adopting slicing and parallel computing.
- RF System Design for 4G-LTE and 5G-NR Applications
  - Optimized RF front-end, RF transceiver, and digital front-end specifications to maximize the competitiveness of MediaTek's cellular products.

RFVLSI Lab, National Chiao Tung University Hsinchu, Taiwan
Graduate Student (Advisor: Prof. Yu-Jiu Wang) *Sept. 2012 – Sept. 2014*

- Circuit Design Optimizer (CDO)
  - Proposed the CDO algorithm to optimize IC design parameters and model fitting.
  - Reduced IC developing time by at least 50% using CDO.
- A Millimeter-Wave In-Phase Gate-Boosting Rectifier (IGR)
  - Designed a 60-GHz RF rectifier that achieved the peak efficiency of 21% and input sensitivity of -7 dBm. Efficiency and sensitivity were improved by 13% and 9 dBm compared to previous works.
  - Published the work on two IEEE papers and one US patent.
- A Millimeter-Wave RFID Passive Tag IC
  - Designed a compact 1 mm^2 RFID tag with the on-chip antenna by increasing the operating frequency and adopting the proposed high-efficiency IGR.
  - Reduced the RFID tag cost by 75% by designing a low-cost on-chip loop antenna.

PROJECTS

NBA Game Prediction System *Feb. 2018 – Present*

- Developed a crawler program in Python to collect NBA data from the website automatically.
- Achieved 76.8% NBA game prediction accuracy in 2017-18 playoffs by the proposed composite 2-stage stacking model consisting of SVM, GBDT, XGBoost, and AdaBoost.
- Built a word cloud generator to represent features of each NBA team by text mining on forums.

PUBLICATIONS

- Yu-Jiu Wang, **I-No Liao**, Chao-Han Tsai, Chatrpol Pakasiri, "A Millimeter-Wave In-Phase Gate-Boosting Rectifier", *IEEE Trans. Microw. Theory Tech.*, vol. 62, no. 11, pp. 2768-2783, Nov. 2014.
- Chao-Han Tsai, **I-No Liao**, Chatrpol Pakasiri, Hsin-Cheng Pan, Yu-Jiu Wang, "A Wideband 20 mW UHF Rectifier in CMOS", *IEEE Microw. Wireless Compon. Lett.*, vol. 25, no. 6, pp. 388-390, Jun. 2015.

PATENTS

- Yu-Jiu Wang, **I-No Liao**, Chao-Han Tsai, Chatrpol Pakasiri, "Current-rectifying device, gate-boosting rectifier and method of permitting current to flow in one direction when driven by AC input voltage", U.S. Patent US20150194907A1, July. 9, 2015.
- Po-Sen Tseng, Wei-Kai Chang, **I-No Liao**, Tzyuan Shiu, Hsin-Hung Chen, Caiyi Wang, "Adaptive Power Amplifier Supply with Pre-distortion Mechanism", U.S. Patent US20170214370A1, July. 27, 2017.

HONORS AND AWARDS

- 2015-2017, MediaTek Inc. VAwards, three times

I-No Liao

PUBLICATIONS

- Yu-Jiu Wang, **I-No Liao**, Chao-Han Tsai, Chatrpol Pakasiri, "A Millimeter-Wave In-Phase Gate-Boosting Rectifier", *IEEE Trans. Microw. Theory Tech.*, vol. 62, no. 11, pp. 2768-2783, Nov. 2014.
- Chao-Han Tsai, **I-No Liao**, Chatrpol Pakasiri, Hsin-Cheng Pan, Yu-Jiu Wang, "A Wideband 20 mW UHF Rectifier in CMOS", *IEEE Microw. Wireless Compon. Lett.*, vol. 25, no. 6, pp. 388-390, Jun. 2015.

PATENTS

- Yu-Jiu Wang, **I-No Liao**, Chao-Han Tsai, Chatrpol Pakasiri, "Current-rectifying device, gate-boosting rectifier and method of permitting current to flow in one direction when driven by AC input voltage", U.S. Patent US20150194907A1, July. 9, 2015.
- Po-Sen Tseng, Wei-Kai Chang, **I-No Liao**, Tzyuan Shiu, Hsin-Hung Chen, Caiyi Wang, "Adaptive Power Amplifier Supply with Pre-distortion Mechanism", U.S. Patent US20170214370A1, July. 27, 2017.

TOEFL iBT® Test Taker Score Report

Name: LIAO, I-NO
Last (Family/Surname) Name, First (Given) Name Middle Name

Email: ino.liao@gmail.com

Gender: M

Date of Birth: 30 Jan 1990

Registration Number: 0000 0000 3117 5631

Test Date: 26 Aug 2017 **Sponsor Code:**

LIAO, I-NO
3F., No.29, Sec. 2, Wenxing Rd.
Zhubei City, Hsinchu County 302
Taiwan

TOEFL iBT Scaled Scores	
Reading	28
Listening	27
Speaking	23
Writing	25
Total Score	**103**

09

Country of Birth: Taiwan

Native Language: CHINESE

Test Center: STN13230A - Global Village Organization ZhongXiao

Test Center Country: Taiwan

Inst. Code | **Dept. Code**

Security Identification

ID Type: Passport **ID No.:** xxxxxxxxxxxxxxxxxxxx6852 **Issuing Country:** Taiwan

Reading Skills	Level	Your Performance
Reading	High	Test takers who receive a score at the **HIGH** level, as you did, typically understand academic texts in English that require a wide range of reading abilities regardless of the difficulty of the texts. Test takers who score at the **HIGH** level, typically • have a very good command of academic vocabulary and grammatical structure; • can understand and connect information, make appropriate inferences, and synthesize ideas, even when the text is conceptually dense and the language is complex; • can recognize the expository organization of a text and the role that specific information serves within the larger text, even when the text is conceptually dense; and • can abstract major ideas from a text, even when the text is conceptually dense and contains complex language.

Listening Skills	Level	Your Performance
Listening	High	Test takers who receive a score at the **HIGH level**, as you did, typically understand conversations and lectures in English that present a wide range of listening demands. These demands can include difficult vocabulary (uncommon terms, or colloquial or figurative language), complex grammatical structures, abstract or complex ideas, and/or making sense of unexpected or seemingly contradictory information. When listening to lectures and conversations like these, test takers at the **HIGH** level typically can • understand main ideas and important details, whether they are stated or implied; • distinguish more important ideas from less important ones; • understand how information is being used (for example, to provide evidence for a claim or describe a step in a complex process); • recognize how pieces of information are connected (for example, in a cause-and-effect relationship); • understand many different ways that speakers use language for purposes other than to give information (for example, to emphasize a point, express agreement or disagreement, or convey intentions indirectly); and • synthesize information, even when it is not presented in sequence, and make correct inferences on the basis of that information.

Speaking Skills	Level*	Your Performance
Speaking about Familiar Topics	Good	Your responses indicate an ability to communicate your personal experiences and opinions effectively in English. Overall, your speech is clear and fluent. Your use of vocabulary and grammar is effective with only minor errors. Your ideas are generally well developed and expressed coherently.
Speaking about Campus Situation	Fair	Your responses demonstrate an ability to speak in English about reading material and experiences typically encountered by university students. You are able to convey relevant information about conversations, newspaper articles, and campus bulletins; however, some details are missing or inaccurate. Limitations of grammar, vocabulary, and pronunciation at times cause difficulty for the listener. However, they do not seriously interfere with overall communication.
Speaking about Academic Course Content	Fair	Your responses demonstrate that you are able to speak in English about academic reading and lecture material, with only minor communication problems. For the most part, your speech is clear and easy to understand. However, some problems with pronunciation and intonation may occasionally cause difficulty for the listener. Your use of grammar and vocabulary is adequate to talk about the topics, but some ideas are not fully developed or are inaccurate.
Writing Skills	**Level***	**Your Performance**
Writing based on Reading and Listening	Good	You responded well to the task, relating the lecture to the reading. Weaknesses, if you have any, might have to do with • slight imprecision in your summary of some of the main points and/or • use of English that is occasionally ungrammatical or unclear.
Writing based on Knowledge and Experience	Good	You responded with a well-organized and developed essay. Weaknesses, if you have any, might have to do with • use of English that is occasionally ungrammatical, unclear, or unidiomatic and/or • elaboration of ideas or connection of ideas that could have been stronger.

This score report provides four section scores and a total score. An analysis of your strengths and weaknesses in English is included. The level pertaining to each skill should not be generalized beyond the performance on this test. Skill levels and their associated descriptions are not intended for use by institutions as part of their admissions criteria and will not be shared unless you grant permission.

Information About Scores: The following scaled scores are reported for the TOEFL iBT test. A total score is not reported when one or more sections have not been administered. These scores have the following ranges:

Sections	Scaled Scores
Reading	0-30
Listening	0-30
Speaking	0-30
Writing	0-30
Total Score	0-120

Score Legends:

Reading Skills	
Level	**Total Scaled Score Range**
High	22-30
Intermediate	15-21
Low	0-14

Speaking Skills	
Level	**Total Scaled Score Range**
Good	26-30
Fair	18-25
Limited	10-17
Weak	0-9

Listening Skills	
Level	**Total Scaled Score Range**
High	22-30
Intermediate	14-21
Low	0-13

Writing Skills	
Level	**Total Scaled Score Range**
Good	24-30
Fair	17-23
Limited	1-16
Score of Zero	0

Institution Codes: The code numbers shown on page 1 of this report are the ones you selected before you took the test. If any institution code you selected is missing, it was incorrect and the TOEFL® Program was unable to send a score report to that institution.

DEPT.	WHERE THE REPORT WAS SENT
00	Admissions office for undergraduate study or an institution or agency that is not a college or university
01, 04-99	Admissions office for graduate study in a field other than management (business) or law according to the codes selected when you registered
02	Admissions office of a graduate school of management (business)
03	Admissions office of a graduate school of law

Additional information about TOEFL iBT scores can be found on the Test Takers section of the TOEFL website at **www.ets.org/toefl.**

* Skill levels for speaking and writing individual skills are estimates of performance at the *item* level. The total writing and speaking scaled scores and ranges are more accurate. Therefore it is not appropriate to combine the individual skill levels. Doing so may lead to apparent inconsistencies between the diagnostic feedback and reported writing and speaking scores.

IMPORTANT NOTE TO SCORE USERS: This PDF score report was downloaded and printed by the test taker. It is not an Official Score Report sent by ETS directly to an organization designated by the test taker. If you find it necessary to verify the scores on this report, please contact the TOEFL Score Verification Service at +1-800-257-9547 or +1-609-771-7100. Scores more than two years old cannot be reported or validated.

TEST TAKER SCORE REPORT

Note: This report is not valid for transmission of scores to an institution.

I-NO LIAO

Address: 3F., No.29, Sec. 2, Wenxing Rd., Zhubei City, Hsinchu County, 30274
Taiwan, China

Email: ino.liao@gmail.com
Phone: 886-938725130

Date of Birth: January 30, 1990
Social Security Number (Last Four Digits):
Gender: Male
Intended Graduate Major: Computer Science (0402)

Most Recent Test Date: February 23, 2018

Registration Number: 2805321
Print Date: September 25, 2018

Your Scores for the General Test Taken on February 23, 2018

Verbal Reasoning

Your Scaled Score: **153**

130 — 170

61st Percentile

Quantitative Reasoning

Your Scaled Score: **168**

130 — 170

94th Percentile

Analytical Writing

Your Score: **3.0**

0 — 6

17th Percentile

Your Test Score History

General Test Scores

	Verbal Reasoning		Quantitative Reasoning		Analytical Writing	
Test Date	**Scaled Score**	**Percentile**	**Scaled Score**	**Percentile**	**Score**	**Percentile**
February 23, 2018	153	61	168	94	3.0	17
November 5, 2017	148	38	166	90	3.0	17
September 23, 2017	150	47	163	83	3.0	17

Subject Test Scores

You do not have reportable test scores at this time.

Your Score Recipient(s)

Undergraduate Institution

Report Date	Institution (Code)	Department (Code)	Test Title	Test Date

Designated Score Recipient(s)

Report Date	Score Recipient (Code)	Department (Code)	Test Title	Test Date

I-NO LIAO

Most Recent Test Date: February 23, 2018

Date of Birth: January 30, 1990

Registration Number: 2805321
Print Date: September 25, 2018

About Your *GRE*® Score Report

Score Reporting Policies

With the *ScoreSelect*® option, you can decide which test scores to send to the institutions you designate. There are three options to choose from:

- Most Recent option – Send your scores from your most recent test administration
- All option – Send your scores from all administrations in the last five years
- Any option – Send your scores from one OR as many test administrations in the last five years (this option is not available on test day when you select up to four FREE score reports)

Scores for a test administration must be reported in their entirety. Institutions will receive score reports that show only the scores that you selected to send to them. There will be no special indication if you have taken additional GRE tests. See the *GRE® Information Bulletin* for details. The policies and procedures explained in the Bulletin for the current testing year supersede previous policies and procedures in previous bulletins.

Scores will be sent to designated score recipients approximately 10-15 days after a computer-delivered test and 5 weeks after a paper-delivered test. If your scores are not available for any reason, you will see “Not Available” in Your Test Score History.

GRE test scores are reportable according to the following policies:

- For tests taken prior to July 1, 2016, scores are reportable for five (5) years following the testing year in which you tested (July 1 – June 30). For example, scores for a test taken on May 15, 2015, are reportable through June 30, 2020. GRE scores earned prior to August 2011 are no longer reportable.
- For tests taken on or after July 1, 2016, scores are reportable for five (5) years following your test date. For example, scores for a test taken on July 3, 2016, are reportable through July 2, 2021.

Note: Score recipients will only receive scores from test administrations that you have selected to send to them.

Percentile Rank (% Below)

A percentile rank for a test score indicates the percentage of test takers who took that test and received a lower score. Regardless of when the reported scores were earned, the percentile ranks for General Test and Subject Test scores are based on the scores of all test takers who tested within the most recent three-year period.

Retaking a GRE Test

You can take the *GRE*® General Test *once every 21 days*, up to *five times* within any continuous rolling 12-month period (365 days). This applies even if you canceled your scores on a test taken previously. You can take the paper-delivered GRE General Test and *GRE*® Subject Tests as often as they are offered.

Note: This policy will be enforced even if a violation is not immediately identified (e.g., inconsistent registration information) and test scores have been reported. In such cases, the invalid scores will be canceled and score recipients will be notified of the cancellation. Test fees will be forfeited.

For More Information

For information about interpreting your scores, see *Interpreting Your GRE Scores* at **www.ets.org/gre/understand.**

For detailed information about your performance on the Verbal Reasoning and Quantitative Reasoning sections of the computer-delivered GRE General Test, access the free GRE Diagnostic Service from your ETS account. This service includes a description of the types of questions you answered right and wrong, the difficulty level of each question, and the time spent on each question. This service is available approximately 15 days after your test administration and for six months following your test administration.

If you have any questions concerning your score report, email GRE Services at **gre-info@ets.org** or call 1-609-771-7670 or 1-866-473-4373 (toll free for test takers in the U.S., U.S. Territories and Canada) between 8 a.m. and 7:45 p.m. (New York Time).

NATIONAL CHIAO TUNG UNIVERSITY

1001 Ta Hsueh Road, Hsinchu, Taiwan 30010, R.O.C.
TEL:+886-3-5724045 FAX:+886-3-5721431

January 31, 2018

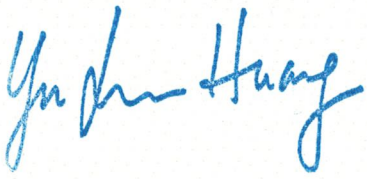
TRANSCRIPT OF THE PROGRAM FOR CONTINUING EDUCATION & TRAINING

Name: I-No Liao (廖以諾) ID Number:F127774112

Program: Credit Program on Colleges of Electrical & Computer Engineering and Computer Science			
Semester Enrolled	Course (graduate level)	Credit	Grade (%)
September 2017~ January 2018	Algorithms	3	99

70 is the passing grade. Below 70=D, 70 to 84=B, 85 or more=A

This transcript is certified as correct according to the official record of the University.



Yu. Lun. Huang
Director
The Center for Continuing Education & Training
National Chiao Tung University

NATIONAL CHIAO TUNG UNIVERSITY

1001 Ta Hsueh Road, Hsinchu, Taiwan 30010, R.O.C.
TEL:+886-3-5724045 FAX:+886-3-5721431

July 31, 2018

TRANSCRIPT OF THE PROGRAM FOR CONTINUING EDUCATION & TRAINING

Name: I-No Liao (廖以諾) ID Number: F127774112

Program: Credit Program on Colleges of Electrical & Computer Engineering and Computer Science			
Semester Enrolled	Course (graduate level)	Credit	Grade (%)
February 2018 ~ June 2018	Data Mining	3	96

For graduate 70 is the passing grade,70 to 72=B-,73 to 76=B,77 to 79=B+,
80 to 84=A-,85 to 89=A,90 or more=A+

The conversion table for grade and grade points(GP)

Grade	A+	A	A-	B+	B	B-
GP	4.3	4.0	3.7	3.3	3.0	2.7

This transcript is certified as correct according to the official record of the University.

Yu. Lun. Huang
Director
The Center for Continuing Education & Training
National Chiao Tung University

Northwestern | THE GRADUATE SCHOOL

Recommendation Form

The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **I-No Liao**

Program: **Computer Science: MS**

Applicant Waived Rights*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Wen-Chih Peng**

Organization Name: **National Chiao Tung University**

Title: **Professor**

E-mail Address: **wcpeng@cs.nctu.edu.tw**

Telephone Number: **+886-35712121#54807**

Relationship to Applicant: **He is my research assistant**

Certification (Date): **10-25-2018**

*"Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters."

Dear Admissions Committee,

The first time I met I-No Liao was in my Data Mining class, and I started to know him better after he joined my research group as a research assistant. Due to his immense potential, great passion in programming, valuable interdisciplinary background, and enterprising personality, I highly recommend I-No to your prestigious graduate program in computer science.

Since the final project proposal in my Data Mining course, I began to notice I-No, whose objective of the project was to predict NBA games. I was deeply impressed by his well-structured presentation. He explicitly defined targets of the project and pragmatically proposed the expected strategies. In addition, I-No was able to thoroughly consider difficulties he might encounter in advance during implementation and provide possible solutions to overcome them. Such an ability was rare among the students. Not surprisingly, owing to his punctilious style, he demonstrated comprehensive analysis and comparisons among different models and methods in the final presentation. The final accuracy of his NBA game prediction reached around 77%. Such a performance was beyond expectations given such a limited time.

Except for the outstanding performance in the final project, I-No stood out among the students by showing strong interests in the contents of the course. He frequently discussed data mining algorithms with me and practically applied those algorithms to his project. With his overall competitive performance, he ranked as the 2nd place in the class among 59 students by achieving a final score of 96 out of 100.

After completing my Data Mining course, I-No joined my research group as a research assistant, focusing on Data Mining and Deep Learning researches. In the Precise Sports project, he led four undergraduate students to develop a badminton trajectory tracking network using Deep Learning techniques. Although he was not experienced in the field of computer science, he showed a fast learning curve and a strong competence in understanding complicated models and programs. Moreover, I-No's engineer background and experiences in the industry brought considerable benefits to the teamwork. He assigned tasks to team members in a balanced manner and mentored each of them patiently, leading to a great team performance and efficiency.

With I-No's exceptional learning ability, the acute sense of programming, and perseverance in personality, I believe he is a perfect candidate for your graduate program. Your solid computer science program will help him develop strong specialized skills and realize his aspirations.

Yours sincerely,
Wen-Chih Peng

Wen-Chih Peng
Director, Institutes of Multimedia Engineering, NCTU
Professor, Department of Computer Science, NCTU
Tel: +886-3-571-2121 #54807
Email: wcpeng@g2.nctu.edu.tw

Northwestern | THE GRADUATE SCHOOL

Recommendation Form

The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **I-No Liao**

Program: **Computer Science: MS**

Applicant Waived Rights*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Yu-Tai Ching**

Organization Name: **National Chiao Tung University**

Title: **Professor**

E-mail Address: **ytc@cs.nctu.edu.tw**

Telephone Number: **+886-35712121#31547**

Relationship to Applicant: **He took my computer algorithms course**

Certification (Date): **10-07-2018**

*"Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters."

Dear Admissions Committee,

It is my pleasure to write this recommendation to support Mr. I-No Liao's application to your computer science graduate program. I have known I-No since he took my course, Design and Analysis of Algorithms, a course covering both basic and advanced algorithms. That is a course in the evening for people working in the Science Industrial Park in Hsinchu, Taiwan. I-No distinguished himself by implementing all the algorithms mentioned in the course using C++ (I didn't ask them to do so) including Fibonacci/Binomial Heap, Prim's algorithm, BFS/DFS, dynamic programming, etc. He got the highest final score of 99/100. 99 was the highest score I could give him even the average was above 99. He was the top student in the course. I have full confidence in his ability to study CS related courses in the graduate level.

I-No's undergradua study was in the Department of Electronics, National Chiao University. At that time, students who had very high score in the exam for entering a university could enter that department. He then worked in MediaTek, an IC design company that always recruits the best students to work for them. He was an RF engineer there. In short, he has been the best from his undergraduate study, to his work, and then in my class.

He realizes that his interest is in computer science, and he would like to apply for the admission to graduate study in computer science. I strong recommend him.

If I could be of any further assistance, please let me know.

Yours sincerely,
Yu-Tai Ching, Ph.D., Professor in Computer Science
Vice Dean, College of Computer Science, NCTU
Tel: +886-3-5131547
Email: ytc@cs.nctu.edu.tw

Northwestern | THE GRADUATE SCHOOL

Recommendation Form

The Graduate School Northwestern University Evanston, IL 60208-1113

Applicant Name: **I-No Liao**

Program: **Computer Science: MS**

Applicant Waived Rights*: **This applicant has waived the right to view their recommendation.**

Recommender Name: **Hsin-Hung Chen**

Organization Name: **MediaTek Inc.**

Title: **Manager**

E-mail Address: **hsinhung.chen@mediatek.com**

Telephone Number: **+886-35670766#21766**

Relationship to Applicant: **Direct manager**

Certification (Date): **10-05-2018**

*"Public Law 93-380, Educational Amendments Act of 1974, grants students the right to have access to letters of recommendation in their placement files. By selecting the "Waive access" option you are waiving access to these letters."

Dear Admissions Committee,

It is my great pleasure to recommend Mr. I-No Liao to your renowned computer science graduate program. From 2014-2017, I-No worked under my direct supervision as an RF system engineer in the RF system department at MediaTek. In my team, I-No took the responsibility for developing DPD (Digital Pre-Distortion) algorithms and defining corresponding 4G LTE system specifications. With solid professional knowledge, an efficient work style, and the ability of cross-functional collaboration, he greatly contributed to the advancement of DPD development. I would rank I-No in the top 5% of all of the young engineers that I have worked with. I strongly recommend I-No to your program.

I-No is a quick learner. When he joined my team, we were trying to build a complex Matlab-based automatic verification platform for the first generation DPD algorithm. I appointed this task to I-No, hoping he could finish it within three months. I-No spent only one and a half month to complete such a task that could be challenging even for senior engineers. In addition to his speed, I-No also did a great job to improve the algorithm. He studied the characteristics of DPD by himself and discovered a new indicator that much more precisely quantified the optimization target. I-No's work refreshed our understanding of DPD, and that was when I found his immense potential of studying algorithms. Thanks to I-No's contributions, two patents were issued regarding our DPD algorithm.

In addition to being an independent learner and a problem-solver, I-No is an excellent team player. The DPD involved at least four different departments and vendors. Efficient communication among different teams were extremely hard but important. However, I-No made things simple. His humble, vigorous, and patient style was appreciated by everyone participated in the DPD project. At the same time, his punctiliousness prevented serious mistakes that might delay our schedule. With everyone's effort, we met the schedule of DPD mass production. I-No's excellent teamwork ability definitely contributed much to make this possible.

I-No has a kind heart, and he is always willing to help. When preparing DPD demonstration at the in-house CTO-exhibition, I-No provided his aid for other two colleagues from another department after completing his own part. He helped them design an automatic demonstration flow which saved engineers from manual operations on instruments when demonstrating real-time DPD functions to the CTO and CEO of our company. I felt very proud of I-No when the supervisor of these two colleagues showed me his appreciation of I-No's help.

When I knew I-No had planned to pursue a degree in computer science, I fully supported his aspiration. Acquiring solid knowledge in computer science from your esteemed program will help him reach his goals. I believe with I-No's ability of self-learning and teamwork, as well as his integrity and warm temperament, he will contribute to your campus as he had done for us. Therefore, I-No has my highest recommendation. Please feel free to contact me if further evaluation on I-No is required.

Yours sincerely,
Hsin-Hung Chen
Manager of RF System I, RF Design, MediaTek Inc.
Tel: +886-3-567-0766 Ext.21766
Email: hsinhung.chen@mediatek.com