Women's History Month Special Article: Interview with "Professor Cynthia Furse"

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Abstract – In this article I had the pleasure of interviewing Professor Cynthia Furse. Professor Furse is not only an internationally well-known researcher in the field of computation and applied electromagnetics (EM), but also an innovator in modern teaching techniques, an entrepreneur, an academic leader, and a true mentor for many young professionals in the electromagnetics field.

Index Terms – women in applied computational electromagnetics, women in STEM.

I. INTRODUCTION

Cynthia Furse (Cindy) is a Professor in the Electrical and Computer Engineering Department at the University of Utah. Professor Furse is a Fellow of the IEEE and the National Academy of Inventors. She is the co-founder of LiveWire Innovation and she was the Associate Vice President for Research at the University of Utah for 10 years. She is well known for her innovative teaching methods in electromagnetics, through flipped classrooms and open-source textbooks. She was the recipient of the 2020 IEEE Chen To Tai Distinguished Educator Award: "For motivating, challenging, educating and inspiring the next generation of EM engineers through innovative teaching, hands-on experiences, current research, and lively participation." This is only one example from a long list of awards for excellence in education and mentoring. Professor Furse is also well known for her research in Finite Difference Time Domain (FDTD) and computational electromagnetics, implanted antennas, and fault detection of live wires. She is currently a member of the National Science Foundation Advisory Committee, a Member of the Editorial Board of the Proceedings of the IEEE, the Award Committee Chair of the IEEE Antennas and Propagation Society, and the Technical Co-Chair of the IEEE Antennas and Propagation Symposium and URSI Symposium 2023. She is truly an inspiration and role model for young women and engineers in this field. If you get the chance to meet her in person, you always see her smiling (Fig. 1). I encourage you to read through this interview, which is in the form of questions and answers, to find many invaluable lessons and advice from Professor Furse.

Fig. 1. Professor Cynthia (Cindy) Furse.

II. QUESTIONS AND ANSWERS (Q & A)

Q: Tell me about yourself.

A: I am an electrical and computer engineering professor at the University of Utah (Fig. 2). I was born in Maine and grew up in Utah. I love rural areas and I enjoy engineering. I got my undergraduate, master's, and Ph.D. degrees all at the University of Utah, where I currently teach. This is a little bit unusual, but it gives me a lot of perspective on the place where I am. My daughter also graduated in electrical engineering and earned her master's and MBA from the University of Utah. My brother also graduated in electrical engineering; he took some classes from me. My youngest brother did a computer science degree from the University of Utah. I have a lot of different perspectives on the place where I teach. I am also an entrepreneur: I started up a spin-off company from my research called "Livewire Innovation" [1].

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Fig. 2. Professor Furse with her famous Smith Chart quilt in the background. She made this quilt and all of her graduate students and senior project students sign it when they are finished with their projects.

Q: When and how did you get interested in engineering?

A: When I was in high school, I thought I was going to be a writer. Later I was going to be a veterinarian. I did an internship at a veterinary clinic. It was awesome. I became very interested in engineering when I did an internship with a pediatrician, and she showed me MRI scans. I decided I wanted to help people like her. Then I thought the person who helped people was the engineer who developed the MRI. MRI was a new technology that got me interested in the fact that engineers make such a difference in the world, and that is how I got interested in engineering. I was in high school when I discovered my interest in engineering. I decided to go into the engineering field right after high school. Engineering is a great way to apply math. I think math is very beautiful and engineers can apply math and use it and build and make things that help people. At first, I started studying mechanical engineering. Later I switched over to electrical engineering when I found so many great applications and many ways that I could use math as an electrical engineer.

Q: When did you become interested in EM?

A: It was in my junior year in college when I took the electromagnetics class from Professor Magdy Iskander. He is one of our very famous electromagnetics professors. It was so exciting and very different from other electrical engineering topics. I love digital and analog, but when I saw electromagnetics and learned that the fields do not stay on a wire, it was like magic, yet it was so predictable by Maxwell's equations. After the EM course, I took computational electromagnetics and really enjoyed it. Magdy accepted me as an undergraduate researcher, and I wrote a paper on my undergraduate research [2]. Then I did my master's under his supervision (Fig. 3). It was a fantastic experience. I learned so much and enjoyed it tremendously. I did some early Method of Moment simulations for hyperthermia for the body and in particular, the head, for applications in brain tumor treatment. After my work on the MoM, I began working with Professor Om Gandhi on FDTD, which is a better choice for modeling heterogeneous media.

Fig. 3. Professor Furse (as a graduate student) performing an experiment in the lab with her supervisor, Professor Iskander.

Q: You mentioned the mentorship of Professor Iskander. Did you have other mentors? What is the role of mentors in students' success?

A: Professor Iskander was an excellent mentor and taught me so much about research and presenting it. I also had other mentors, including some of the other graduate students in my office in the department. They always had good advice for me. They were people whom I could associate with. Even in high school, my physics teacher was the first mentor to ask me if I had thought of engineering when I did not know much about engineering. I think mentors are important for all of us. Overall, I have had quite a lot of mentors in my career. Each mentor has some strength, and when you learn from the mentors you learn from their strengths. I think when I have a variety of mentors I learn from the best in the field. I think I have more mentors now than when I was a student.

Some mentors are more senior than me, and some are even junior. It is a matrix of mentors. You always need mentors. For example, when I was associate vice president for research, the vice president of research was a great mentor who showed me how to lead a large group of people. I'd never had that experience before. I also benefited from his mentoring in teaching.

One of my favorite mentors is Professor Balanis. When I was a young student, I walked up to him when he had won an award, and I told him I wanted to be just like him. To date, he is still my mentor. I asked my students what is the most important I can do for them as their mentor. They said the most important thing for a mentor is honesty. If someone is not doing well, the mentor should honestly tell them and show them the ways that they can do it better. You can see how my students are giving me advice that I could use.

Q: You have a passion for teaching and always look for innovative methods of teaching. Please explain more about your teaching activities.

A: Sometimes people see teaching and research as separate tasks, but they are not separable. They are two important pieces of the puzzle that go together. One thing that motivates me to be innovative and creative in my teaching is that when I was taking my junior year in engineering it was difficult. Some concepts and topics were hard. Sometimes my classes were just so hard that I cried. Sometimes, I didn't feel I belonged. Now, I look for ways for my students to learn and understand engineering topics happily, efficiently, and easily. I am always looking for ways to improve my teaching (Fig. 4).

Fig. 4. Professor Furse teaching an undergraduate class.

There have only been a few ways that electromagnetics has been taught, yet there are some teachers who are more inspiring than others. I would like to be one of the inspiring teachers and look for ways that excite my students. For example, one of the strong innovations that I have been involved with is the flipped classroom. I adopted the flipped classroom before even it had a name. I was teaching and I had students who through their military assignments had to leave and had no option to take the class for a year. To help them I video-recorded my classes on CDs or DVDs and sent them to these students. I quickly realized that the video lectures were so helpful to those students, and gradually other students came and asked me if I could make them available to them too. I put them in the library and made them accessible to all students. Students who had already come to the class used them to review the material, and they mentioned to me that they could not possibly pick up all the details that I thought in class, and having access to the video lectures helped them to review the lecture.

Tablets were just becoming available, and I couldn't even get a tablet – I ordered a tablet, and it was back ordered for like two or three months. I made my first video lectures with my little camera on a tripod and a whiteboard. You see me in those early lectures walking back and forth to turn the camera. It was not fancy at all, but they became so successful. Soon I realized that I could buy more time for my students. I always felt like when I delivered a lecture and the students would think they understood it, just to learn when they started doing their homework and needed me, I was not there to guide them. They would randomly shop for equations and try to get the answer. I thought that I wanted to "be there" when they were working on the homework problems. I tried so many ways to get more time in my class, I tried to do my lecture faster, but it just didn't work. After recording those video lectures, I realized that I could use the video and move the lecture out of class time. Students could watch it in advance and then we could spend the class time actively working on the problems together. As soon as I did that it just magically made more time and therefore more interaction with the students. They learned more, did better and liked it more. So, it turned out that the frustration with the amount of time I had in the class is what led me to do this flip class, which was in 2007, more than 10 years before COVID started [3]. The pandemic, of course, was a complete disaster, but it led to a phoenix rising out of the ashes. Only a fraction of my colleagues were using flipped classes before, now almost all of them are using them. Now both the teachers and the students have an amazing set of new skills and can collaborate remotely via many different tools. We have learned to be able to communicate effectively with our students. Not only we can work remotely but also sometimes we are enjoying and preferring it. We've learned that if we have the hybrid version of classes where students can either come to class in person or they can join online, there is no reason to miss a class. The flip class is now becoming a "hybrid flipped class" or a "hy-flex class".

Now, anyone can pick the right location and the right timing for them to learn, and we stop thinking of the class as the people sitting down right now in the class and that is the only way you can learn. This can also enable us to invite anyone to join us from anywhere, and that opens a huge amount of flexibility that we haven't even scratched the surface of yet. I think there will be more collaborations and universal universities. Because our fundamental classes are similar among different universities, while the senior-level classes are mostly based on our specialties and there are only a few specialties in every department. If we could share our specialized classes, I think we would all become stronger. I know that it requires changes in the policies related to admission and tuition but if we share our classes mutually it will be more efficient for both parties, and that creates tremendous opportunities for our students, and yet that would be a fair arrangement. We would be sharing and collaborating equally, so I hope we do start seeing more of this teaching collaboration than we ever had before.

Q: From medical implants to finding the faults in aircraft wiring, why is applied EM important, and how it can solve problems?

A: Since the waves are invisible and you cannot see the electromagnetics, sometimes people won't realize that they're there doing important things for them. There are three important areas that electromagnetics excels, and it is even more important now than it was before.

Sensing: An example is medical imaging such as MRI and microwave radar imaging. With electromagnetic waves that can travel through the body, we are now able to look for tumors or cancers. This is like using radar imaging and the use of electromagnetic waves that travel into the ground helping us to look for oil or buried landmines. We see that electromagnetics is important in all kinds of sensing. In my research, I used sensing to find faulty wires in aircraft while the plane was working. This is a vital application because you don't want the plane to crash and sometimes these problems only happen during the flight. By the time the airplane comes back to the ground, we may not be able to locate that fault.

Communication: We can attach data to waves. Modulating the data into electromagnetic waves to be able to communicate, and send video, sound, and other types of data over long distances is a very familiar way of using electromagnetics. Cell phones now are used for all sorts of communication. Can you imagine if we had to be dragging a wire from place to place with our cell phones?! Wireless communication is an important application of electromagnetics. That includes optics. Fiber optic cables are now used for carrying data and are an essential part of communication.

Treatment: Another important application is the treatment of diseases. One of the earliest applications that I worked on was hyperthermia. That is a method of producing heat in the body (like how we use microwave ovens to heat food). By heating the tumors, you target the cancerous cells and kill them while the rest of the body is intact.

We now have so many tools, more than when my career started. We have simulation tools to simulate a portion of the body like the brain or the spinal cord. You can buy chips and put together antennas, and you can directly print antennas onto the circuit board. We have more tools and powers to creatively come up with new devices.

Q: You are a successful researcher, a passionate teacher, an inventor, and active in academic administration and scientific societies and groups, yet you find time to spend with family and have many hobbies. How do you do it all, what is your secret to work–life balance?

A: I don't know if there is a secret and often feel as if there isn't a balance. I do a lot of different professional activities, but I value my family and the fun that I like to have so very much that I don't leave it out. I learned early to schedule time and to plan so that I could do things with my kids. I made sure we did something after dinner: playing or doing homework, or doing other activities. Sometimes I felt anxious because I knew that I had more of my work waiting but it was so important to me to spend time with my young children. And now I have grandchildren and I look for opportunities to play with them. I get to see them almost every weekend and that is just delightful; I look forward to the time I spend with them. There are so many other things that I could be doing, there is always another paper or grant to be written and I am behind on things. I am always behind on some things, but I just had to schedule and plan that time for critical and important things in my life. I don't think there is a secret, but "prioritization" is essential. Prioritization does not mean when I spend time with my family, I don't get my work done, and it does not mean I get my work done and I don't spend time with my family. It means that I recognize that these two priorities are both important and they are both going to need time. It does mean that I am behind on things, and I don't do as much as I might have done if I did not spend time with my family or go horseback riding on the weekends (Figs. 5 and 6). I have chosen the set of priorities that I apply and that is different for each person. We need to respect that some people want to spend more time in one place than the other, and during different periods of their life. That does not mean you are "balanced", what it means is that you made a choice, and you should choose how you want to spend your time. I think that is the secret: "choosing the priorities and planning how to spend the time".

There is a secret after that, which is when you are with your family, doing your hobbies, or walking quietly in the woods, you should not feel guilty or unhappy that you are not working hard. You need to relax, let your mind take a break and let it do some of its jobs on its own. We all get more creative when we are fresh when we can relax and step away from problems. We feel the frustrations especially when we work very hard on something, and it is not working. Often, for engineers, this is the case. So, I might be working so hard that I can't figure it out. After I've tried everything, I don't know what else to try next. If I step away and I spend the morning horseback riding, or I go for a walk with the dogs, or

I cook dinner with my husband, those are the times that my mind will sort out the problem and give me the next thing to try. If we don’t give our minds that break, they can’t do their job. If we deny ourselves the time to spend with family and friends and for ourselves to do our hobbies, or be with our pets, we are not going to be better at our work, we will be worse. Making time makes you better.

Fig. 5. Professor Furse, during one of her horseback ridings.

Q: As you are aware, the percentage of female students in this field has always been very low. What are the reasons for this and what steps can be taken to increase the percentage of female professionals in this field?

A: This is a funny question for me because I am here and did find a way and I do love it. I don’t know why everyone wouldn’t because it is so much fun and rewarding. Any type of science that you learn deeply has got to be exciting. We learned electromagnetics and it is exciting, fun, and fascinating. You think you may learn everything that you needed to know in the first two or three or four or ten years, but no, there are so many more things to learn. I think that many women would enjoy this now, so why might they choose something else? When you talk with a young woman who is exploring all the beautiful options before her – maybe someone in high school or maybe someone who is coming back for another career – you must look at the entire world of things that she could do and there are many options. Frankly, some options compete with engineering fields, such as medicine, law, sociology, and other excellent careers. For a young woman who is doing well in school has every opportunity in

Fig. 6. Professor Furse, hiking with her husband.

front of her, we are competing with these other opportunities. In high school, you cannot possibly have the perspective of what any of these fields feel like. I was unusually fortunate to be able to do a series of job shadows. My dad, a professor, made arrangements that I could do job shadows and see what it was like in different jobs. That made a huge difference. Creating more opportunities to spend time exploring all professions including engineering help all our students, men, and women, to recognize the things that they might find fascinating and the places where they might feel that they best fit in. When a young woman comes and does a job shadow, she also needs to see that our culture is welcoming and supportive. It must be appealing and there are times that I would have to say it is not. We need to fix that. I had a female graduate student who once told me “I don’t want to be a professor because you work too hard.” Then I realized that I had not been transparent and not told them about my great joys, such as spending time with my family or doing hobbies. That made me realize that I should not be hiding those anymore. Now, for example, I tell my students that I’m going horseback riding and I won’t be in cell phone service for a while.

When a young woman comes and looks at our profession when she does a day of a job shadow with us, she needs to see that all the managers treat everyone kindly, all the professors treat their students kindly, and the students treat each other kindly. She needs to see that engineers are doing things that make a difference in the world. She needs to see that there are growth opportunities in every place for everyone, not just for her brother or her uncle, but for her too. She needs to see that she could move up to be a professor, a department chair, a vice president, or the president of the university. She needs to see an industry where not only she can work as an entry-level engineer but also, she can move up to become a manager. She needs to see that the individuals that a female engineer is managing will respect her and want to work with her. If she does not see that in the place where you are working, you need to change it. Some places need this change, and some places have made this change, and you know what? They are getting the best of everything. They are getting the best women and men engineers. They are getting the best diverse engineers. They are getting the best of everyone because they have made an environment that works for people. If your job environment is not like that, if you cannot bring your daughter and expect her to love it, you need to change it and make it better. Then you will be able to get the best of everything.

Tiffany Iskander, my Ph.D. student (Magdy's daughter), and I did a study on the number of women in engineering [4]. We found that sometimes the reason is cultural. In the United States, students get guidance from high school counselors. In some cases, we found that many counselors didn't realize how fantastic the engineering profession could be for a woman. Consequently, they often did not encourage bright female students to consider pre-engineering classes such as math, physics, and chemistry. They were much more likely to encourage a young male student to consider engineering. In some cases, they specifically felt that engineering was not a good career for women because there were so few women in it. We as engineers do need to reach out broadly around us and be generous with our time and energy to talk to our neighbors, our nieces or nephews, our friend's kids, and anybody who wants to come and talk to us.

Q: Do you have a memorable moment in your teaching or research that you like to share?

A: Let me share one related to your previous question on work–life balance. When I came up with the idea that turned into a company [1], I was working on finding faults in aircraft wires. I was in a group that had done a statistical evaluation of the wires. The goal was to decide when the wires must be replaced. Would it matter how many times the airplane had been used? Would it matter if it was hot or cold or wet? Would it matter if the wires went by the engine where it is hotter than it is in the regular aircraft? They were doing statistical analysis and they could not find evidence that would tell them when the wire had reached the end of its useful life. The data was showing some very peculiar results and one of the things was that most of the faults were within a foot or two of the connectors, and not along the entire length of the wire. Statistically, you would expect that if the wire was aging these types of faults would be uniformly distributed along the length of the wire. Since the faults were close to the connector it became pretty apparent that was due to mechanical stress. It might have been a maintainer disconnecting the wire for repair, drilling, or something else that happened nearby. It was happening due to an unpredictable human interaction with the wires. Therefore, the types of faults could not be statistically related. They almost always happened in flight. When they were not being used they would not show a fault. During the flight, when the wires started vibrating, going up in the air, getting wet or cold or warm, they failed. Because airplanes have been built for durability there are typically three copies of every critical system so if one fails there are two spares, that is why our planes are successful. When an airplane had a problem up in the air, they needed to locate it and fix it later. This was a clear problem in the aircraft industry, and I developed what is known as a reflectometer. We could use time domain reflectometry (TDR) to locate a fault on a wire, but the trouble was we could only use TDR on dead wires on the ground. We even built a frequency domain reflectometers system in a little box and took it to the North Island Lake Navy base, and we could not find the faults unless the wires were not active. This was because you can only find an open circuit when the wire is open, and can only find a short circuit when the wire is short-circuited. I kept saying we need to be able to find these on "live" wires. It was months after that and I tried so many ways I knew, trying all kinds of filters. Then during that time once my kids and I was visiting my parents.

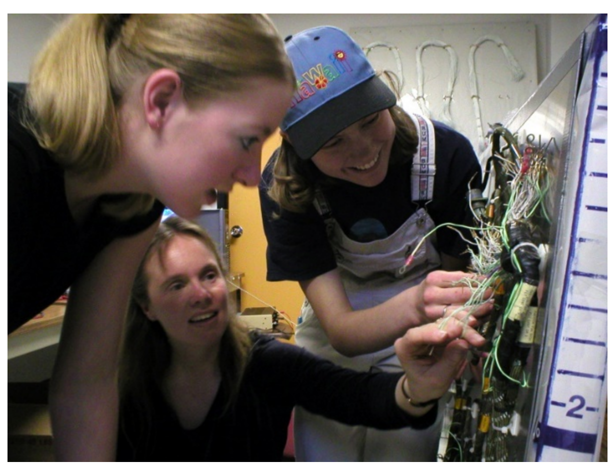

Fig. 7. Professor Furse and her students working on their research on live wire fault detection.

I was taking a shower and I watched the water randomly dripping down the shower glass door. Then I thought to myself: "Oh my gosh, I need a random signal, I need a pseudorandom signal, I need a CDMA (code division multiple access) type system, I need a spread spectrum system!" It was one of those times when I had left my work and was just relaxing and my mind did its job. It was what I needed. That idea led to the development of spread spectrum time domain reflectometry (SSTDR). It is a system that uses a pseudo-noise code and enables testing of the energized wires' impedance changes and can find faults in those wires. It is the idea behind my spin-off company, and a part of my research work today (Fig. 7). That moment of inspiration led me to the invention. It did not happen when I was working at my desk but when I was out playing.

Q. Do you have any advice for students and young professionals who are interested in the field of applied EM?

A: Just jump in and get involved. If you are a student interested in research, work with a faculty. Do a senior design project related to research through an undergraduate research experience, volunteer in a lab, and follow the professor through the day doing a job shadow. Get a good summer internship or get involved in a research experience for undergraduates (REU) through the National Science Foundation (NSF) [5]. Don't be satisfied with just the classes. Classes are important but get involved in the excitement of your field, get involved as early as you can.

To young professionals, those who have already graduated and are working their first or maybe their second job: this is a very exciting time. You have learned a lot in school, but oh my goodness, there are a lot of things to learn at your first job. You are becoming a true professional. At that point be infinitely curious. Find out what you must know. Find out about the other exciting things that are going on at your company, or other companies. Join IEEE and find out what's going on at companies around you. Talk to the people that you graduated with and find out what they are doing. Just be infinitely curious.

To senior professionals too: do the same thing, just be infinitely curious. Always look for interesting stuff in the world around you (Fig. 8). It does not have to be something that you'll use today. It might be just fascinating and you might use it sometime in the future. You cannot innovate in a field by only knowing and using the old techniques. You need ideas from other fields. That was how my innovation happened. It came out of communication theory. It was an old method in communication theory, but it was new for wire testing. You need to learn not only the topics that you use at this very moment but just be curious about the cool things around you so that you can apply them in creative ways.

Fig. 8. Professor Furse in an anechoic chamber measuring an antenna.

Q: Do you have any additional comments?

A: Electromagnetics is the coolest thing in the world. The electromagnetic community that I have experienced has been so welcoming and embracing, creative and fun. I think it is an excellent community for new people who want to come in and join and it is a great place for women.

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