Researchers develop better antenna for ground-penetrating radar, EMF immunity testing

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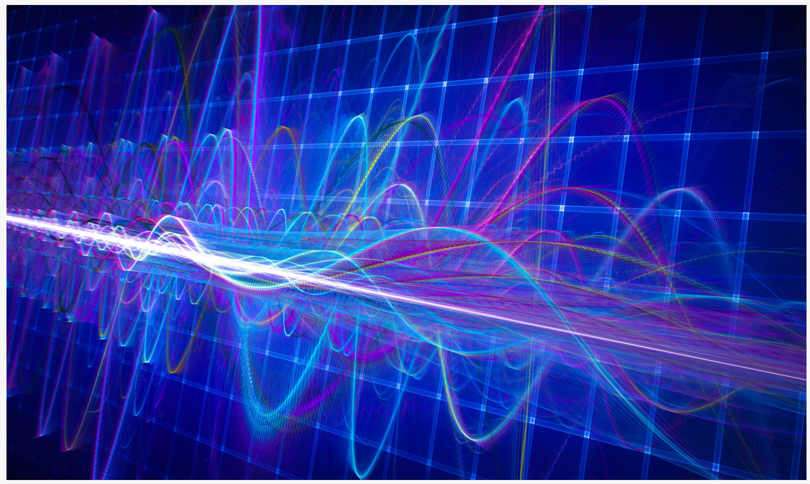

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ABU DHABI, UNITED ARAB EMIRATES, UNITED ARAB EMIRATES, October 12, 2021 /EINPresswire.com/ -- Researchers at the Directed Energy Research Centre (DERC) in the UAE's Technology Innovation Institute (TII), have discovered a significant improvement to an old antenna design that promises to enhance high-energy devices for ground-penetrating radar, electromagnetic immunity testing, and scientific research.

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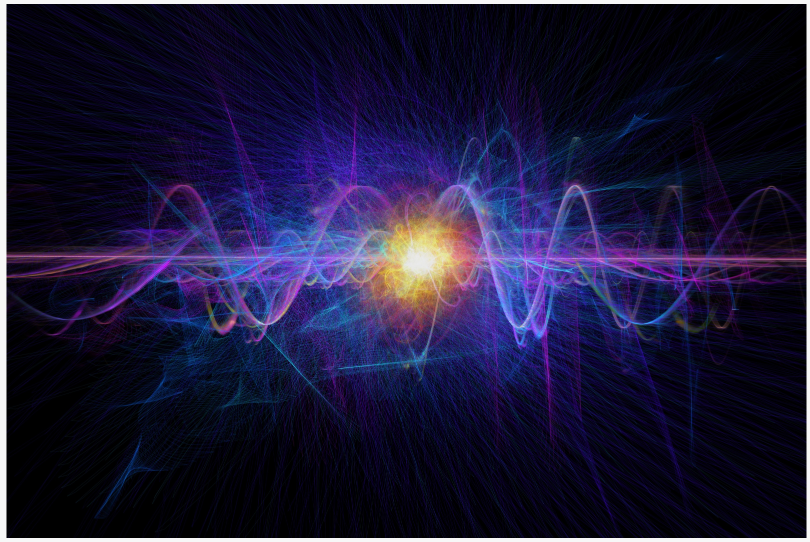
>
> *Dr Felix Vega, Director of Electromagnetic Research and Development at DERC*

Most antennas are designed for applications with a narrow bandwidth and limited power, allowing designers to shrink them to a relatively small size, such as that of a cellphone. But researchers have struggled to build efficient antennas for ultrawideband applications that might require the use of signals with a bandwidth wider than about 500 MHz. In addition, some of these devices need to accept impulse signals with tens of kilovolts of amplitude with nano second duration.

Carl Baum developed the original Impulse Radiating Antenna (IRA) design in the 1990s to handle high-power ultrawideband radio transmissions. Other researchers developed models to explain how the antenna worked over the next decade. However, the fundamental antenna design has not evolved since then.

This new design uses a novel approach that eliminates the need for a special coupler to match the impedance between the impulse generator and the antenna.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Technology Innovation Institute (TII)

The problem of impedance

A signal generator produces electrical signals into an appropriate format, or waveform for the desired EMF application. These generators typically have an impedance of 50 ohms, which is the international standard. Therefore, the antennas must also be designed to receive 50-ohm signals to accept as much energy as possible from the generator. However, the traditional impulse radiating antenna has an optimum impedance of 100 ohms, so a transformer was required.

Dr Felix Vega, Director of Electromagnetic Research and Development at DERC, said: "The main disadvantage of the generic IRA is that it cannot be directly connected to a commercial generator."

This additional component, designed to withstand the high-power levels across a wide bandwidth, adds to the already considerable expense. Vega worked with a company many years ago that used to sell these antennas. He found that many clients complained about having to buy a new custom-made impedance adaptor. The antenna cost about US$10,000, and then the impedance adaptor added a further US$3,000.

The costs for a complete system could run much higher. The signal generator alone might cost about US$50,000 to US$70,000. And equipment for ground-penetrating radar can cost up to US$100,000 owing to the need for a bi-static antenna to send and receive signals, and a special receiver that further adds to the expense.

Advantages of a half impulse radiating antenna

This new design embeds the impedance adaptor in the antenna itself. As a result, it is possible to connect the antenna directly to the signal generator. The antenna consists of two parts, a parabola and a pair of arms for transporting energy from the signal generator. The shape of the arms automatically transforms the impedance. "It is an impedance transformer embedded into the antenna," Vega said.

As simple as this may sound, the mathematics for designing the precise shape is not trivial. Vega said: "It requires a certain degree of complex analysis, which is one of the reasons it has not been done before."

In previous designs, the arms of the antenna were triangular plates with a constant impedance. "For me, it was natural to think about having something that was not constant in shape, so that you can achieve the impedance transformation," Vega said. The concept functions like a graded-index lens by progressively changing the structure's geometry to attain the desired electrical properties. In this case, the structure and geometry changes rather than the index of refraction of the material.

An extra component, like a transformer, is always an additional challenge when designing high-performance radio frequency devices. Furthermore, the transformer must be insulated to withstand the high voltages being applied in these devices and requires a computer numerical lathe to cut the right part in 3D.

The new antenna design is flat - enabling it to be easily cut at any workshop with a 2D cutting tool. The frequency losses are also easier to minimise because the space between the arms is essentially insulated by the air, which is also the medium in transporting the EMF signal. In contrast, a traditional transformer is insulated by plastic that tends to disperse the waves, much like sand on a beach disperses water waves.

Future work

Early prototypes of the new design are used for applications such as testing out the effect of intense EMF radiation on electronic devices to help protect them against solar flares and electromagnetic tomography applications. Down the road, Vega would like to explore new types of devices using the same principle. For example, DERC’s researchers might use a graded-index lens instead of a parabola. This lens would collimate the wave in the forward direction instead of the parabola reflecting the wave.

This process could be more flexible since it is easier to customise the size and shape of the dielectric lens by progressively baking layers of material with different dielectric constants to achieve the desired properties. The new design would also reduce the need to cut the parabola to a precise shape and size using special equipment. "It is a more forgiving manufacturing technique," Vega said.

Tania Ameer
APCO Worldwide
+971 52 672 5138
tameer@apcoworldwide.com