Vubiq Networks' RFID Hyperimaging Patent Portfolio Executive Summary

Vubiq Networks' portfolio of five millimeter wave (MMW) radio frequency identification (RFID) hyperimaging technology patents cover the company's unique data encoding technology that exploits the natural physics of antennas at a tremendously small scale. The result is a chipless RFID data tag that approaches the cost of printing a bar code, but with the ability to contain hundreds of data bits in the size of a postage stamp.

Utilizing the company's innovative polarimetric synthetic aperture radar (POLSAR) hyperimaging techniques, not only can the data be retrieved from the tag, but also physically located. This breakthrough approach to RFID significantly reduces cost, while providing performance advantages and features not available with existing solutions and competitive approaches.

The company's technology addresses all the downfalls of traditional RFID solutions. The chipless technology addresses today's biggest barrier: the cost of the RFID tag. The company's innovative approach reduces tag costs to near pennies per tag. With POLSAR as the technique for the RFID reader, multiple tag collisions are no longer an issue. And with the use of millimeter wave as the frequency spectrum, reader performance increases and wireless disruption is minimized. Utilizing POLSAR hyperimaging as opposed to traditional RFID methods greatly expands the use cases by providing the ability to read multiple tags simultaneously, as well as determining their three-dimensional location.

View an animated video demonstrating Vubiq Networks' RFID hyperimaging technology.

Table 1. Frequency Range

	Low Frequency (LF)	High Frequency (HF)	Ultra High Frequency (UHF)	Vubiq Networks RFID MMW
Frequency	30KHz – 300KHz	3MHZ – 30MHz	300MHz – 3GHz	60GHz – 240GHz
Range	10cm	10cm – 1m	12m	12m+
Data rate	Very slow	Slow	Fast	Very fast

Table 2. RFID Tag Types

	Active (Chipped)	Passive (Chipped)	Vubiq Networks (Chipless)
Power Source	Yes	No	No
Integrated Circuit	Yes	Yes	No
Cost	Expensive	Moderate to expensive	Very low cost
Printable	No	In some cases	Yes
Range	Long 12m+	Typically shorter range	12m+ and customizable
Multiple Simultaneous Tag Reads	No	No	Yes
Security	Depends on chip	Low	Highly secure
Tag Location Determination	No	No	Yes

As articulated by research from IBM, hyperimaging is an exciting new technology space that is poised to dramatically change the world in many ways. The current $11 billion RFID market is expected to grow to $40 billion by 2025, portending a bright future for the company's hyperimaging technology innovation.

Vubiq Networks' RFID hyperimaging patents include:

- US Patent Number 7460014 – RFID System Utilizing Parametric Reflective Technology
- US Patent Number 7498940 – RFID System Utilizing Parametric Reradiated Technology
- US Patent Number 10839179 – Multimode Millimeter Wave RFID Systems and Methods Thereof (23 Claims)
- US Patent Number 11216625 – High Bit Density Millimeter Wave RFID Systems, Devices, and Methods Thereof
- US Patent Number 11288468 – Multimode Millimeter Wave RFID Systems and Methods Thereof (33 Claims)

Modeling and Simulation Validates Technology Claims

Vubiq Networks has successfully modeled its RFID technology. Utilizing industry-standard 3D radar computer simulation and MATLAB algorithm implementation supplied by Ansys and MathWorks, the company has been able to validate the technology claims of its RFID patent portfolio.

The company has successfully completed start-to-finish system-level simulation/post processing that clearly shows how its patented technique of encoding data into tiny millimeter wave antenna tag elements leverages the natural polarization and phase properties of those elements. The company can now model the full RFID reader technology as a polarimetric FMCW radar using the latest 3D electromagnetic CAD tools from Ansys, combined with solving image formation and polarization/phase detection with its algorithms implemented in MATLAB."

With the completion of modeling and simulation, Vubiq now has the blueprint for creating unique tag elements that support low-cost, high-bit density tags for many of today's RFID applications.

Historical Background

Historically, there have been several technologies used to identify articles, objects, vehicles and personnel. Bar codes and magnetic strips, for example, are familiar as traditional, short-range solutions. More recently, RFID techniques have been developed that improve on performance and readability. RFID technology utilizes a tag transponder – typically a small integrated circuit (IC) – that is placed on the object to be tagged, as well as a reader (or interrogator) to read and identify the tag.

One of Vubiq Networks' first innovations for millimeter wave applications was a completely new approach to RFID. The company recognized that current technologies use a relatively expensive integrated circuit in the RFID tag that sets the lower boundary for system cost. Also, there are technology limits in terms of reading multiple tags simultaneously and not having the ability to retrieve the physical locations of the tags.

At the time, Cardinal Health expressed an interest in solving the RFID problem at a lower cost for their healthcare logistics operations. Early funding for Vubiq Networks' research came from Cardinal Health, resulting in a laboratory proof of concept (POC) that showed how the company's millimeter wave POLSAR technology could be used to produce radar images of the tags and to decode the tag data.

Vubiq Networks' technology patents secured the encoding of data by leveraging the natural physical properties of antennas, in this case very small (millimeter wave) antennas that could be arranged in groups to form a new version of the RFID tag. Since Vubiq Networks was using an imaging radar

technique, the company was also able to retrieve the physical, three-dimensional location of the tags, and could decode hundreds of tags simultaneously.

The POC was successful in developing the fundamental millimeter wave transmitter and receiver technology needed to create the millimeter wave POLSAR system. Vubiq Networks was now on the threshold of providing future innovations in hyperimaging component and system technologies.

US Patent Number 7460014, issued December 2, 2008:
RFID System Utilizing Parametric Reflective Technology

This initial technology patent set the stage for Vubiq Networks' RFID hyperimaging innovation. The patent defines a method for encoding and decoding information by using millimeter wave radio frequency antennas, including one or more reader (interrogator) devices and RFID data tags. The RFID tags include multiple antenna elements that are formed on a substrate or directly onto an object. The antenna elements are oriented and have dimensions to provide polarization and phase information that represent the encoded information on the tag.

The reader scans an area and uses millimeter wave radar hyperimaging to create an image of the scanned area. The reader receives reradiated RF signals from the antenna elements on the tags, with the tags represented on the image. The reradiated RF signals include polarization and phase information of each antenna element. The information is used with radar signal imaging algorithms to decode the information on the tag.

Read the patent

Patent Number 7498940, issued March 3, 2009:
RFID System Utilizing Parametric Reradiated Technology

As a follow-up to the 7460014 patent above, the 7498940 patent provides additional protection for Vubiq Networks' innovative RFID technology. While the 7460014 patent sets out *Method* and *Use* claims (describing how the technology is actually used to produce the results), the 7498940 patent sets out *System* or *Apparatus* claims (describing the specific technology and how it is put together and how it operates, independent of how it is used.) Covering both method and system provides a high degree of protection for the company. In addition, the 7460014 patent emphasizes the *Reradiaton* functionality of the antenna elements of the RFID tag.

Read the patent

US Patent Number 10839179, issued November 17, 2020:
Multimode Millimeter Wave RFID Systems and Methods Thereof (23 Claims)

This patent further expands and protects Vubiq Networks' existing RFID hyperimaging technology in conjunction with a new reader design that performs wide-beam POLSAR, narrow beam reads from chipped tags, and narrow-beam reads and communications with chipped tag and Internet of Things (IoT) devices.

This patent application expands the company's protection for its unique data-encoding scheme that exploits the natural physics of antennas at a tremendously small scale. The patent covers breakthrough technology with dual mode capabilities for identification and communication with various types of RFID

tags and smart sensors using POLSAR while in a wide-beam pattern mode, and then shift to a narrow-beam steered mode for powering and communicating with the tags and IoT sensors.

The company's advanced radar imaging technology can locate various types of both chipless and chipped RFID tags, as well as IoT devices, with a very high degree of accuracy. Once the tags or devices have been located, the technology can power and communicate with the RFID tags in the far field.

Read the patent

US Patent Number 11216625, issued January 4, 2022:

High Bit Density Millimeter Wave RFID Systems, Devices, and Methods Thereof

This patent application defines advanced, high-bit density chipless RFID technology using the company's POLSAR technique that incorporates polarization and phase detection. The new technology covered by this patent provides orders of magnitude higher bit density for RFID tags as compared to "prior art" or other competitive approaches.

This patent application will provide additional worldwide protection for Vubiq Networks' RFID technology. The technology described in this patent application will lower costs by enabling the use of low electrical conductivity metals for the antenna elements, avoiding costly silver-based inks. Vubiq Networks has been able to achieve this breakthrough due to the fact that the technology is not relying on spectral signature response, but instead relies on radar cross-section and antenna reradiation mechanisms.

This patent application includes "reduction to practice" by addressing both hardware and software techniques. It provides for very high density chipless tag data encoding through the use of innovative geometrical layout of the patch antennas as the tag elements. The technology provides for optimized element spacing, providing very high bit density for chipless RFID.

The company's technology not only provides for greater bit density, but also greatly lowers the cost of RFID tags, which is a very important consideration for emerging IoT applications and smart objects.

Read the patent

US Patent Number 11288468, issued March 29, 2022:

Multimode Millimeter Wave RFID Systems and Methods Thereof (33 Claims)

Vubiq Networks has been issued two patents that cover multimode RFID. The fundamental concept for multimode is that the RFID system is capable of millimeter wave SAR imaging radar and decoding of imaged RFID tag elements, along with precise spatial location of those elements and tag in the first mode. A second mode switches the RFID reader from a wide area scanned SAR imaging radar to a narrow area beamed wireless communications system. The purpose is to both detect and decode the RFID tag in the SAR mode, and if the tag also has the ability to return data in a more traditional transponder mode of communications, the second mode supports the communications and can retrieve data from the tag or send control signals to the tag for implementing various functions such as used with IoT capable tags as an example.

The first patent (10839179) has an independent system claim describing the RFID reader architecture, and a second independent method claim describing the same reader architecture, each with a set of dependent claims referencing their independent claims respectively.

The second patent (11288468), which is a continuation of the first patent, has an independent method claim describing a computing device which controls the RFID reader as specified by the same architecture as the first patent, a second independent system claim describing an RFID control computing device which controls the RFID reader, and a third independent system claim describing a non-transitory, computer-readable medium having stored instructions for operating the RFID reader. The dependent claims for each independent claim are the same as in the first patent.

Since the second patent is a continuation filed based on the first or parent patent, the title, specification, and drawings are identical. The difference is in the claims language as described above.

The second patent, by claiming a computing device and non-transitory, computer-readable media which controls the RFID technology significantly broadens the patent coverage.

Read the patent

Ongoing and Future Developments

Vubiq Networks in now in the process of expanding on its RFID hyperimaging innovation by incorporating newly available millimeter wave silicon technologies that have integrated radar functions and digital signal processing on the same chip. The ability to do multi-channel polarimetric radar – coupled with advanced image processing in low-cost commodity chips – breaks the cost barrier for enabling RFID reader technology into the hyperimaging artificial intelligence (AI) realm. Vubiq Networks remains on the cutting edge of bringing together the physics of millimeter wave wireless combined with advanced digital signal processing software for hyperimaging applications.

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Making Millimeter Wave Ubiquitous

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