COJOT

MORE THAN ONE WAVELENGTH

Increasing Tactical Wireless Network Performance With Switched Beam Antennas

A White Paper

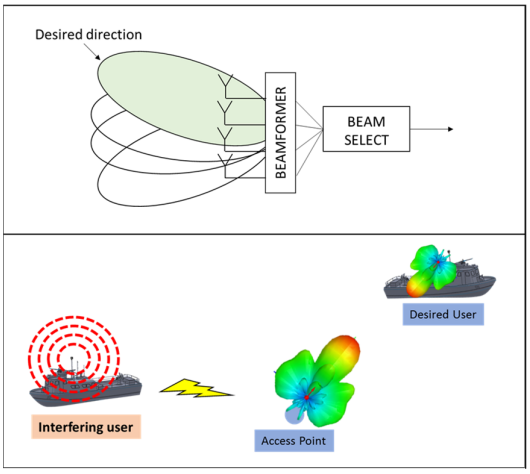
Introduction

Spectrum management and spectral efficiency are key factors in modern cellular tactical networks in addition to network performance. Performance enhancement regularly occurs at the cost of spectral efficiency or the implementation of the antenna nodes becomes extremely complex and less economical. The utilisation of switched beam antenna in the network can enhance network performance, spectrum management and spectrum efficiency. On top of that a switched beam antenna is a cost effective solution.

COJOT SBA in NAVY tests

The Principle of Beam Steering

Various beam steering solutions have existed for a number of years in telecommunication networks. Beam steering functionality can be achieved using various techniques including rotating a single antenna element, but these solutions are neither fast nor flexible as well as having higher maintenance costs. On the other hand the most sophisticated solutions like adaptive beam steering requires a radio front end for each antenna element resulting in increased processing power making them less practical and less economical. A switched beam steering utilising a number of fixed beams/antenna elements can be a good compromise. In a conventional switched beam solution the beam steering is established by creating and shaping an array from the antenna elements with mechanical switches. Using electrical switches the RF performance, switching speed, total number of switching cycles and the cost structure can be further improved.



Beam steering principles

Beam steering logic and control

The control logic of a beam steering antenna is basically simple: The antenna beam should be steered from the base station towards the mobile user or vice versa, based on the strongest signal level. In some situations the beam could be steered away from the direction of interference as a means to improve link performance. A SBA forms multiple fixed beams in particular directions. These receiver/antenna systems detect signal strength, select one of several predetermined fixed beams and switch from one beam to another tracking the user through the sector. This simple logic could be also implemented inside the SBA by using simple beacon signals. A beam steering functionality opens up lots of new features for a tactical multi-node network such as serving multiple clients in a frame rate, quick joining to a network, interference avoidance, advanced radio signal routing, low probability detection etc. Therefore, it is most beneficial that the beam steering logic is integrated to the radio network utilizing its processing power and signal information.

COJOT SBA features

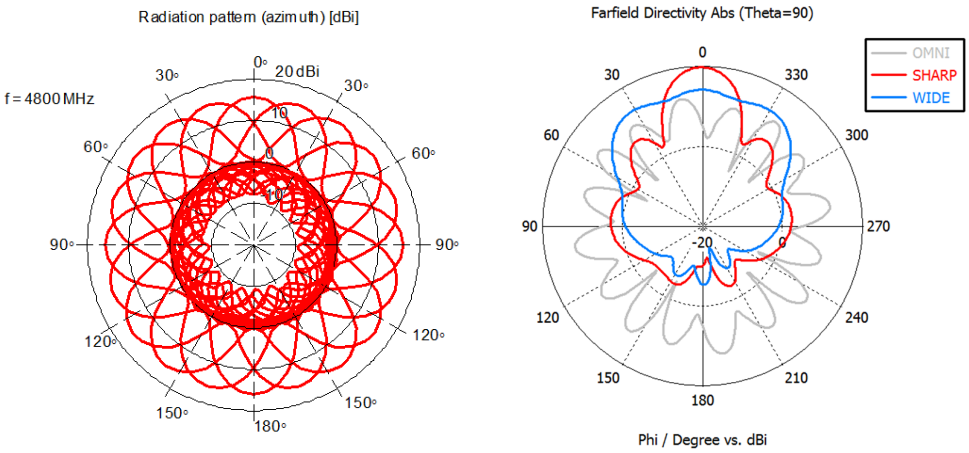
The beam steering in COJOT SBA antennas is implemented with an inventive combination of element switching and phase shifting. The unique switching matrix is able to combine various antenna elements to form different beam modes with the lowest loss, in a fast and economical way. In detail the COJOT SBA contains for example 20 identical antenna elements installed as a cylinder. Based on this configuration the SBA can provide up to 20 beams with a minimum of about 20-degree beamwidth to cover the full 360-degree horizontal area. With a built-in switching matrix these 20 antenna elements can be enabled and combined various ways to enable the antenna to provide a range of beamwidths and support for simultaneous beams to be established in different directions allowing for multiple users and applications. Other antenna configurations are available and can be adapted to meet customer requirements. Mechanically COJOT has concentrated on improving the usability, robustness, size and weight of the antenna. For example the dimensions of the UHF IV antenna SBA4450B are 270 mm x 390 mm (diameter and height) including the mast mounting element, weighing approximately 4kg. The mast mounting element which can be installed without tools and the molded fiberglass radome are critical enhancements from the user point of view.

Different beam modes

The basic functionality of the COJOT SBA is to provide a directional beam with narrow beamwidth in a controlled direction. This beam mode is called as Sharp beam. In Sharp beam mode the SBA provides 20 beams, approximately 25-degree in horizontal (azimuth) plane, with 18-degree (360° divided to 20 sectors) separation. These beams can be switched on in random order, one at a time. The figure below shows an example of a 20 element solution, displaying the all measured sharp beams (azimuth) in the same graph for the SBA4450B at 4800 MHz.

In addition to the Sharp beam the SBA can provide also wider beamwidths, even some simultaneous beams and omni-like radiation patterns to improve link budget for multiple close by nodes. The typical beamwidth for the wide beam is 90 degrees in the horizontal plane. This mode can be used for example to serve multiple clients in this sector or to provide faster network scanning.

The figure below shows also the different beam modes in a single elevation pattern graph.



20 different sharp azimuth beams and different beam modes of SBA4450B.

Control Interface

The control interface in COJOT SBAs is based on full-duplex RS-485 utilizing a fast and simple communication protocol containing acknowledgements. The cable used to connect to the antenna is standard with two twisted pairs and therefore for example standard EMP filters can be easily used. With the fast controlling interface combined with fast switching components the SBA antenna can support modern Software Defined Radios' (SDR) hopping and frame rates. In the COJOT SBA the total switching time including the communication is below 35 microseconds. This field proven control interface is also used in other COJOT active/smart antenna products.

Benefits

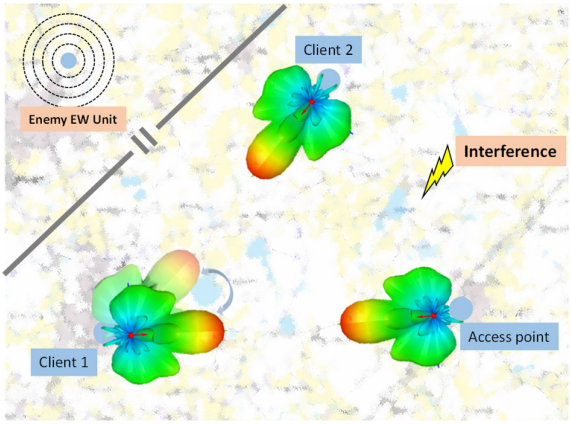
The COJOT SBAs can provide multiple benefits for a complex tactical multi-node network. Obviously not all enhancements can always occur at the same time and some require more intelligence from the radio system but overall the enhancements SBA can provide to the user are remarkable.

Better coverage and extended range

The SBA can provide the same azimuthal 360 degree coverage as an omni directional antenna. As the SBA can make use of narrower azimuth beams to enhance antenna gain, it in practice means that the single node geographical coverage can easily be multiplied many times compared to an omni directional antenna. As for a free space point to point connection every 6 dB (decibel) increase will double the link length, the usage of SBAs can easily extend the link distance for example three times. This can be put to numbers with practical comparison with an omni directional antenna providing 6 dBi gain and an SBA providing 15 dBi gain. When an SBA is used at both ends of the link, the antenna gain benefit will be 18 dBi which equals 3 x 6 dBi (every 6 dB will double the link length). For a link three times 10 km gives 30 km. For omni directional coverage ($A=\pi r^2$) this similarly means $\pi 10^2 = 313$ km^2 versus $\pi 30^2 = 2827$ km^2. In real life all links obviously do not operate in free space and therefore the propagation losses are higher but the antenna gain will obviously give advance also in those situations.

LPI/LPD functionality

LPI, LPD are acronyms for Low Probability of Intercept/Low Probability of Detection. In practice this relates to possibility to interfere or detect of the transmissions across a tactical wireless network. A switched beam antenna improves the resistance of the wireless network against these threats. When a narrow antenna beam is directed in one direction instead of omni coverage, the receiving level of interference and noise reduces significantly. With the SBA the spectral signature is much smaller when the signal is transmitted only in a selected direction. Similarly, restricted directions for example towards enemy troops, can be defined and the system configured to automatically avoid those. In a case where interference is coming from a certain direction, the SBA can be used to reroute the signal. It should be also highlighted that the SBA helps improve the spectral efficiency of the network by minimizing interferences caused by its own transmissions and therefore decreasing the frequency re-use distances.



SBA enhances LPI/LPD resistance

Performance

Enhanced antenna gains and lower noise levels improve the link budgets across the network. This results in a better network capacity and faster response times. With improved signal to noise ratios the radios can operate at higher modulation rates and provide higher data rates. Similarly, enhanced signal levels for users close to cell edges will improve the system overall performance.

Support for Mobility

It can be said that the SBA combines the benefits of omni directional and directional antennas. An omni directional antenna is often needed to provide a wireless connection to a moving vehicle. The down side of the omni antenna are pretty well listed above: Coverage and spectrum management. On the other hand a directional antenna would require some sort of controlled rotating element to follow any signal of interest. With the SBAs adjacent antenna elements signal strengths can be monitored constantly, for example between transmission cycles, therefore transition to a new direction is managed fast and effectively allowing the SBA to “track” the selected signal of interest.

Automatic and quick network setup and management

An SBA can be used to improve some basic routines in a wireless network. In a mobile network when a new node is added to the network a practical problem is to find correct direction for the best signal. Quite often some manual method is used, for example rotating a directional antenna, however in many cases this can be time consuming and errors can easily happen. Also, if the connection is not full line of sight connection, then the direction for the best signal may vary. With the SBA this routine can be made much faster and with a more reliable result. If the signal strength is strong enough the node can immediately join the network with the omni mode, followed by using the SBA to search for the correct narrow beam directionality to achieve the strongest signal strength. Similarly the wide beam mode provides faster scanning time. The possibility to

utilize sharp beams with in a frame rate over the 360 degree area opens up many possibilities for network management and usage of advanced network routing protocols like OSPF (Open Shortest Path First).

Summary

The use of Switched Beam antennas can enhance the usability, performance and spectrum management of complex tactical multimode networks in various ways. Improved signal levels through enhanced antenna gain enlarges the cell sizes or enable faster data rates. Many modern doctrines define the criteria for even tactical wireless backbone networks to support mobility, similarly minimizing the spectral signature and evading the interference are critical aspects from a tactical point of view. The Switched Beam Antenna can provide a perfect solution to meet those combined requirements.

About COJOT

COJOT is a well-respected and long established Finnish company, designing and developing VHF/UHF/SHF antennas and accessories for mobile tactical communication, electronic warfare and spectrum monitoring applications. At the moment COJOT is offering three variants for switched beam antennas that are:

- SBA4450B: Switched beam antenna for 4400-5000 MHz frequency range
- SBA1327B: Switched beam antenna for 1350-2700 MHz frequency range
- SBA2458DB: Dual Band Switched beam antenna for 2400 and 5800 MHz frequency ranges

For more information about COJOT and Switched beam antennas contact:

contact@cojot.com

Or visit our website:

https://www.cojot.com/product-category/switched-beam-antennas/

COJOT OY │ P.O.Box 59 │ 02271 ESPOO │ FINLAND │ Tel. +358 (0)9 452 2334 │ Fax +358 (0)9 452 3696 │ www.cojot.com