C-BANDI UYGULAMALARI İÇİN ANTEN PERFORMASINI GELİŞTİREN DAİRESEL POLARİZASYONLU DİZİ ANTEN TASARIMI

ÖZET

Günümüzde alıcı, verici sistemlerinde iletişimin kaliteli olması için anten tasarımı çok önem taşımaktadır. Antenin bir devrimi sayılan Mikroşerit antenler birçok özelliklere sahip oldukları için kablosuz haberleşme, radar ve uydu haberleşmesinde kullanım alanı bulmuştur. Kolay üretilebilmesi, boyut olarak az yer kaplaması bu özelliklerdendir. Bunların yanı sıra, dar bantlı olması ve yüksek kazanca sahip olmaması bu antenin dezavantajlarındandır. Bu sorunların çözümü olarak, dizi antenler önerilir. Dizi antenler tasarıma bağlı olarak, daha fazla bant genişliğine ve kazanca sahiptirler. Birden fazla antenin yan yana veya farklı kombinasyonlarla bir araya gelmesi birkaç yan etkiye de sebep olacaktır. Antenlerin birbiriyle etkileşimleri ve daha büyük boyuta sahip olmaları, dizilerin dezavantajlarındadır. Tasarım açısından, antenlerin dizilişinin yanısıra, besleme tipleri de önem taşımaktadır. Kaynaktan gelen gücü doğru paylaştırmak ve istenilen zaman ve faz gecikmesini yaratmak besleme şebekesinin görevlerindendir. Dolayısıyla, iyi tasarlanmış besleme şebekesi dizi anteniyle birlikte iyi bir performans doğuracaktır. Dizi antenler yüksek kazanca sahip oldukları için, uydu haberleşmesi, DSB (Direct Broadcasting Service), WLAN (Wireless Local Area Networks) ve uzay haberleşmesi gibi birçok uygulamada kullanılmaktadır.

Uydu haberleşmesi, WLAN, DBS, GNSS (Global Navigation Satellite Systems), RFID (Radio Frequency Identification), WPAN (Wireless Personal Area Networks) GNSS, WiMAX (Worldwide Interoperability for Microwave Access) ve kablosuz haberleşme gibi uygulamalarda doğrusal polarizasyon yerine dairesel polarizasyonlu antenler tercih edilir. Bunun sebebi, dairesel polarizasyonunun sağladığı avantajlardır. Bu avantajların birkaç tanesi aşağıdaki gibidir. Alıcı ve verici antenler dairesel polarizasyonlu olduğu takdirde doğrusal polarizasyonlu antenler gibi ilk ayarlara ihtiyaç duymayacaktır. Dairesel polarizasyonlu anten kullanarak polarizasyon uyumsuzluk kayıpları da önlenmiş olur. Dairesel polarizasyonlu antenler kullanarak çok yollu etkileşimler ve kayıplar da önlenebilir. Sağ dairesel polarizasyonlu işaret (Right-Hand Circular Polarization (RHCP)) vericiden gönderiliyorsa, ortamdan alıcıya doğru yansıyan işaret sol polarizasyonlu olduğu için (left-hand circular polarization (LHCP)) girişim önlenecektir. Ayrıca uydu haberleşmesinde karşılaştığımız Faraday rotasyonu kaybını da giderme kabiliyetine sahiptir.

Uydu haberleşmesi, mikrodalga radyo haberleşmesi ve radar gibi uygulamalar C bandında çalıştıkları için tasarlamak istediğimiz antenin C bandında olması planlanmaktadır. C bandı IEEE tarafından 4 GHz'den den 8 GHz aralığına kadar tanımlanmıştır. Bu bantta çalışmanın avantajları, birçok alana uygun olmasıdır. Örneğin hava tahmini uydularında Ku bandı yerine C bandı kullandığımız da yağmur zayıflatması (Rain Fade) denilen kayıpları oldukça azaltabiliriz.

Bu çalışmada C bandı için uygun dairesel polarizasyonlu dizi antenler tasarlanıp performansını artırmak için yöntemler sunulacaktır. Tasarım esnasında ilk olarak, dizi antenin bant genişliği ve kazancı üzerinde çalışılacaktır. Bunun için önce dairesel anten elamanının tasarım metotları tartışılıp performansı artırılacaktır. Uygun bir anten tasarlandıktan sonra, antenin dizilişi ve besleme şebekesi üzerinde çalışılıp Butler matrisi gibi yeni besleme şebekeleri sunulacaktır.

CIRCULARLY POLARIZED ARRAY ANTENNA DESIGN WITH EMPHASIS TO ENHANCE THE ANTENNA PERFORMANCE FOR C-BAND APPLICATIONS

SUMMARY

The C band is a name given to certain portions of the electromagnetic spectrum, including wavelengths of microwaves that are used for long-distance radio telecommunications. The IEEE C-band (4 to 8 GHz) and its slight variations contain frequency ranges that are used for many satellite communications transmissions, some Wi-Fi devices, some cordless telephones, and some weather radar systems. For satellite communications, the microwave frequencies of the C-band perform better under adverse weather conditions in comparison with the Ku band (11.2 GHz to 14.5 GHz) microwave frequencies used by other communication satellites.

The increasing demands for more capacity and higher data rate in wireless systems have led to the development of broadband CP antennas. During recent decades, a variety of broadband CP antennas have been proposed for applications in mobile satellite communications, WLAN, DBS, RFID, GNSS, space communications and wireless power transmission systems.

The CP antenna is very effective in combating multi-path interferences or fading . The reflected radio signal from the ground or other objects will result in a reversal of polarization, that is, right-hand circular polarization (RHCP) reflections show left-hand circular polarization (LHCP). A RHCP antenna will have a rejection of a reflected signal which is LHCP, thus reducing the multi-path interferences from the reflected signals. The second advantage is that CP antenna is able to reduce the 'Faraday rotation' effect due to the ionosphere. The Faraday rotation effect causes a significant signal loss (about 3 dB or more) if linearly polarized signals are employed. The CP antenna is immune to this problem, thus the CP antenna is widely used for space telemetry applications of satellites, space probes and ballistic missiles to transmit or receive signals that have undergone Faraday rotation by travelling through the ionosphere.

Another advantage of using CP antennas is that no strict orientation between transmitting and receiving antennas is required. This is different from linearly polarized antennas which are subject to polarization mismatch losses if arbitrary polarization misalignment occurs between transmitting and receiving antennas. This is useful for mobile satellite communications where it is difficult to maintain a constant antenna orientation. With CP, the strength of the received signals is fairly constant regardless of the antenna orientation. These advantages make CP antennas very attractive for many wireless systems.

For a circularly polarized microstrip antenna, both axial ratio and impedance bandwidths need considerations. Use the array antenna is a recognized methods to increase axial ratio bandwidth and gain of circularly polarized antenna. for better result in increase the impedance bandwidth and decrease the array mutual coupling prepare feed network have to design too.

In this thesis, with attention to advantage of CP antenna and C-band application as mentioned above, will be tried to generate a CP array antenna by broadband feed network and antenna element. In order to achieve mentioned CP array antenna, three aspects will be considered. In first step (aspect 1), will be focused on feed network. For this purpose, will be employed broadband microwave components such as

broadband power divider, broadband hybrid coupler and broadband phase shifter instead of equal narrowband component that hitherto, have been utilized. Use of broadband CP antenna element with high gain will be the second priority. To achieve broadband CP element, use of slot antenna and in order to attain high gain element, use of cavity back structure are recommended. In this case, the single element must be changed polarization diversity because the feed network will be able to change polarization diversity and for this purpose, polarization of element and feed network should be coordinated. In third step (aspect 3), method of location element in array such as distance between element, mutual coupling between them and feed network will be significant. Also, communicate between feeding in array feed network and antenna elements, in order to impedance matching and power transfer, have important role.

Thus, In order to achieve the above mentioned goals antennas were created as follows:a 3 dB axial-ratio of the CPSSA extends to approximately 2 GHz. The CPSSA was designed to operate over the frequency range between 3 and 11.1 GHz corresponding to an impedance bandwidth of 115% for VSWR<2. Acceptable agreement between the simulation and measured results validates the proposed design (section 2.1). And then a compact size of 20×20 mm^2 CPSSA in section 2.2 is reported. The measured impedance bandwidth is as large as 11050 MHz (2950–14000 MHz) or about 130.38% with respect to the center frequency. The measured 3-dB AR is 3373 MHz (35.7%) from 3729 to 7102 MHz and the average measured gain of CPSSA is almost 3.5 dBi in the operating band.In oder to attain array antenna by broadband CP antenna elements in section 2.3 and 2.4 two type of antenna with novel methodes in designing feed network are reported. In first case a array antenna which feed by sequentially rotated feed network is mentioned. the 3 dB axial-ratio bandwidth of the this array antenna extends to approximately 1.3 GHz and was designed to operate over the frequency range between 4.5 and 6.4 GHz corresponding to an impedance bandwidth of 34.86% for VSWR<2 (section 2.3). in section 2.4 by modified feed network and array elements the characteristics of array was improved. The reported array consists of 2×2 CPSSA elements and is fed by a novel feeding network consisting of the circuit strip-line couplers and delay lines. The feeding technique is applied to the 2×2 antenna array to increasing the axial ratio (AR) bandwidth. The measured impedance bandwidth for VSWR < 2 is around 78.5% (3.4 – 7.8 GHz) and 3dB axial-ratio bandwidth is about 35.7% (4.6–6.6 GHz) and average 14.2 dBic gain over the 3 dB ARBW. In final, in order to investigate of broadband feeding network and elements on array antenna, two type of array with capable to change polarization and pattern diversity are reported (sections 2.5-2.7). for example in sectin 2.5, a array antenna by changing to polarization diversity by broadband vivaldi antenna is reported and in section 2.6, a beam steering array antenna composed of a broadband circularly polarized square slot antenna and a novel Butler matrix feed network designed with a broadband branch line coupler is introduced. The Results show that a compact and its improvements are discussed. In this work a broadband double box coupler with impedance bandwidth over 5 - 7.4 GHz frequency and the phase error less than 3 degree is employed. Also the measured impedance bandwidth of the proposed beam steering array antenna is 39% (from 4.7GHz to 7 GHz). The minimum 3dB axial ratio (AR) bandwidth between ports, support 4.55 - 6.7 GHz frequency range. The measured peak gain of proposed array antenna is 10.1 dBic that could scan solid angle approximately 25 steradian.