CHARACTERISTICS OF HORIZONTALLY POLARIZED ANTENNAS FOR POLARIZATION DIVERSITY IN THE 400MHz BAND

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1. Abstract

Base station antennas for private mobile communications with VHF/UHF bands require significantly high performance and reductions in size in order to respond to increasing telecommunications demands and expanding telecommunication configurations in a new generation. It is not possible to use present antenna technology, due to the low operating frequencies. Despite the fact that even further reductions in size will become necessary, this issue has for the most part not been studied. This paper proposes polarization diversity antennas [1] [2] as a method of responding to these demands. Based on the characteristics of polarization diversity antennas derived from simulations, we produced a prototype horizontally polarized antenna for polarization diversity in the 400 MHz band and conducted an investigation of this unit's characteristics, with a view toward practical implementation of such antennas.

2. Introduction

Private mobile communications encompass a wide range of applications aimed at the smooth implementation of communication-related operations in many diverse fields. These include public sector activities such as electric power and gas companies, as well as fire-fighting and police operations, transport and taxi businesses, and a variety of manufacturing and sales operations. Private-related telecommunications mainly use frequencies in the 150 MHz and 400 MHz bands. Diversity technology [3], which incorporates reception by several antennas, is one method of lessening the deterioration of communication quality in mobile telecommunications; this method generally uses spatial diversity. When utilizing spatial diversity in base stations, correlation decreases because this method requires distances of between 5 and 10 times the wavelength of the radio wave used for communications, and as a result a sufficient diversity effect [4] can be seen. Because wireless private mobile communications apply relatively low frequencies (150MHz and 400MHz), the required antenna interval will be anywhere between 2λ and 10λ more than for mobile communications (portable phones, PHS phones, etc.) used in public telecommunications. As a result, it is difficult to establish an arrangement of antennas that will obtain a sufficient diversity effect.

We believe that the most appropriate method of attaining diversity in base stations is the polarization diversity method [5], [6], which takes up relatively little physical space.

By applying the polarization diversity method, it is possible to build up small diversity systems because the antennas need not be separated spatially. Also, because the antennas themselves are small, it becomes possible to reduce the area exposed to wind and to keep station installation costs down as well. This is why research into polarization diversity antennas [7], [8] has been conducted.

Studies have been made into the applicability of various types of polarization diversity antennas, which receive both horizontally and vertically polarized components through slots, patches, or loops, in mobile communication base stations for public telecommunications [9], [10]. Nevertheless, the use of antenna configuration methods using low frequency ranges such as 150MHz and 400MHz (the frequency bands used for Private communications) has for the most part not been studied, because of the need for even further reductions in the size.

In this paper, we used elements of an “H-type” configuration to illustrate the possibility of practical applications of polarized diversity antennas in base stations.

3. Features of the Antenna

The antennas used for polarization diversity are wire-type antennas, for which physical configuration is also easy. Figure 1 illustrates the antenna configuration. It is a turnstyle antenna that uses a half-wave dipole antenna for vertical polarization and an H-type antenna element for horizontal polarization. The H-type antenna element is comprised of a basic half-wave horizontal dipole antenna element that is bent upward to make an H-type, with a short bar added to adjust the impedance of the element. The antenna for horizontal polarity is a turnstile configuration with these elements placed in an orthogonal arrangement. In the case of this H-type antenna, it is possible to reduce the horizontal inner plane by reducing L1, but there is a tendency for the impedance to drop as a result. On the other hand, we can increase the actual impedance part by appropriately positioning the shortbar that is provided with the element. It is therefore possible, by adjusting these components, to satisfy the characteristics through the physical configuration. Currently, the H-segment length (L1: from the feed point to the point where the antenna bends upward) is 10 mm; the vertical length from the bend point (L2) is 179 mm; and the interval from the feed point to the impedance adjustment shortbar is 20 mm. The interval (d) between element A and element B is 1.0 mm. In terms of the impedance characteristics of the antenna in the simulation, the real part achieved impedance of 42.8Ω. These antennas also omni-directional radiation pattern in the horizontal plane.

When positioning the various polarization antennas for polarization diversity, considering the omni-directional pattern in the horizontal plane. and the reduced size of the physical configuration, it is preferable to position all of the polarization antennas on the same axis. Figures 2, 3, and 4 show S21 characteristics when vertical polarization elements are placed in each possible position in reference to the horizontal polarization element (H-type element B). Here, the horizontal polarization elements are positioned on the xz plane, with the feed point as the starting point of the coordinate system. The vertical polarization elements are placed at the position of the feed point on the xy plane, and at the position x = y = 3.3 mm on the z axis. In terms of the characteristics, S21 will be less than -20dB when the vertical polarization elements are at any of the following positions: [x = y = 3.3 mm], [x = 3.3 mm, y = 62.8 mm], or [x = y = 34.9 mm]. Considering the reduction in size of the configuration mentioned above, the optimum positioning would be when the interval between each element is at a minimum (x = y = 3.3 mm, z = 0). At this time, the correlation coefficient obtained between the antennas for each polarization is 4.71×10^{-5}.

4. Prototype testing

The configuration of the prototype horizontal polarization antenna for polarization diversity in the 400 MHz band is shown in Figure 5. The antenna’s feed system carries out a balance-to-unbalance conversion through a balun near the element’s feed point, and then runs downward via an unbalanced power line (a coaxial line) where it is connected to a hybrid or other circuit. Because a 0.3 mm fine copper line is used in the element and a 0.86 mm diameter semi-rigid coaxial line is used for the feed line, the entire antenna is fixed in place using styrofoam supports. The orthogonal orientation of elements A and B eliminate any contact between the two elements, by securing an interval [d] along the z axis (vertical) for the positioning coordinate of element A in relation to element B. The power line is positioned at coordinates having the feed point of antenna element B as the starting point, and with the center at x = y = 1.5mm.

Figure 6 illustrates an example of the impedance characteristics at the feed terminals, when each antenna feed terminal has a matching impedance of 50Ω, which is equivalent to that of the connecting circuit. The solid line shows estimated values for the prototype antenna, and the broken line shows calculated values from simulations. In this case, there is a balance-to-unbalance conversion between the feed terminal and the antenna in the prototype unit, but because the simulator being used is not capable of calculations that take this into account, corrections have been made in the estimated values. In the prototype test, we can see an error that appears to be due to the balun, but we have confirmed that these characteristics are close to the calculated values for both the real and the imaginary impedance parts.

5. Conclusions

In the context of base stations for private mobile communications in VHF/UHF bands, we have proposed a polarization diversity antenna with a goal of achieving higher performance and smaller systems that will be compatible with the high-performance mobile telecommunications predicted to appear in the future. In the proposed method, H-type elements are used as the horizontal polarization element. Based on simulation characteristics, we produced an actual prototype of a horizontally polarized element, and experimentally confirmed the element's basic characteristics. We produced a prototype antenna in the 400 MHz band, and confirmed that these characteristics are close to calculated values based on the characteristics of the prototype tests, while in the process demonstrating the possibility of practical applications. In the future, we plan to continue promoting the popularization of both diversity antennas and array antennas.

6. References

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Figures

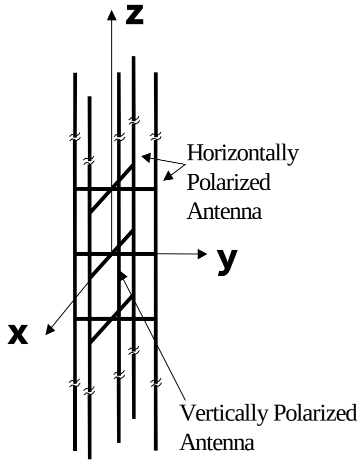

Fig.1:Composition of Antennas

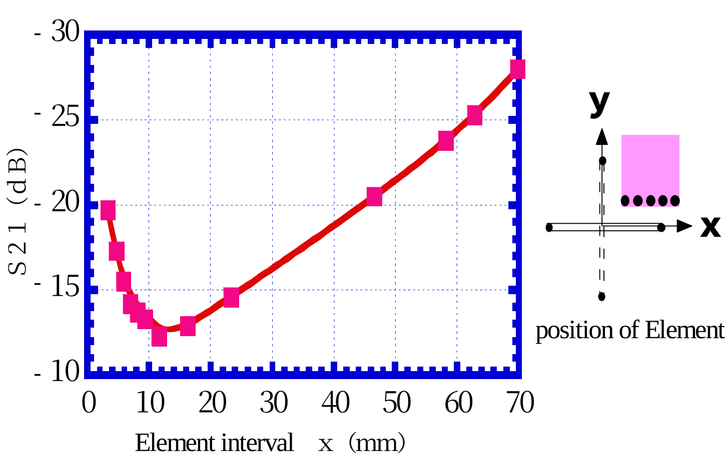

Fig. 2: Element interval & S21; y = 3.3mm, z = 0mm

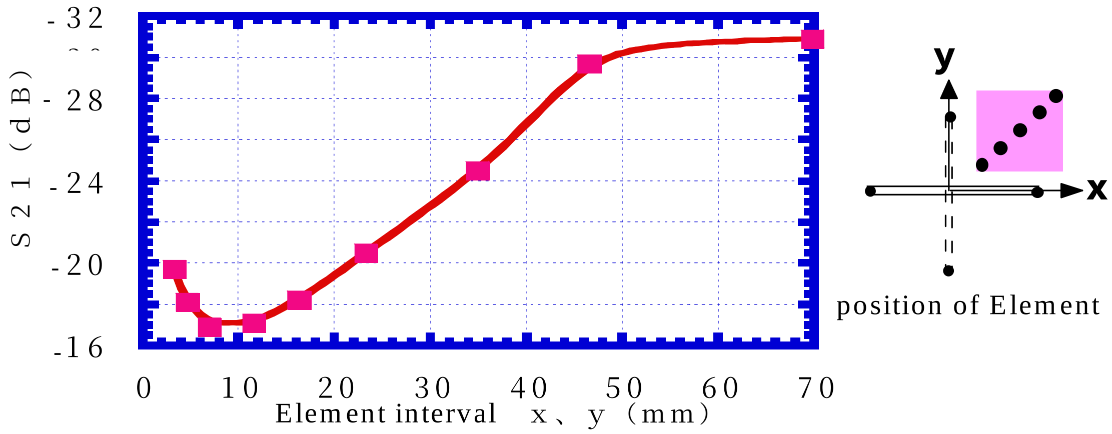

Fig. 3: Element interval & S21; x = y、 z = 0mm

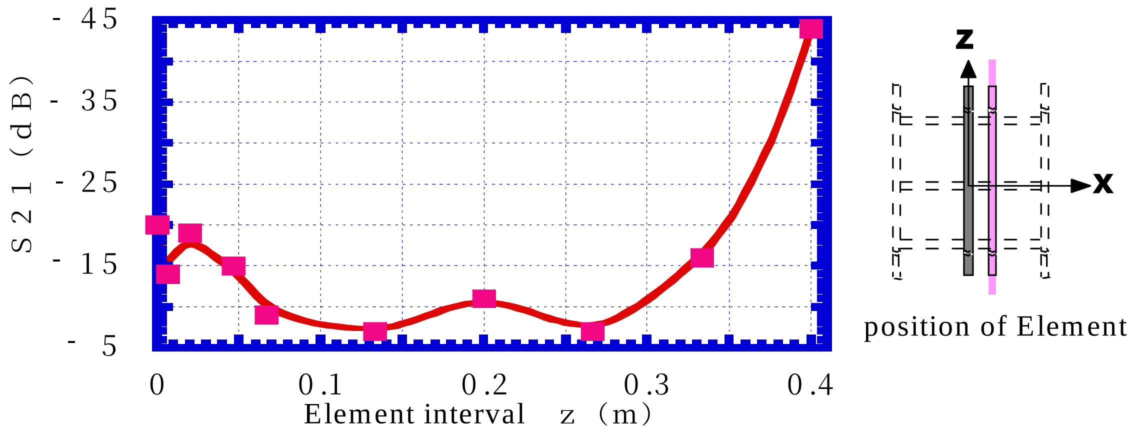

Fig. 4: Element interval & S21: x = y = 3.3mm

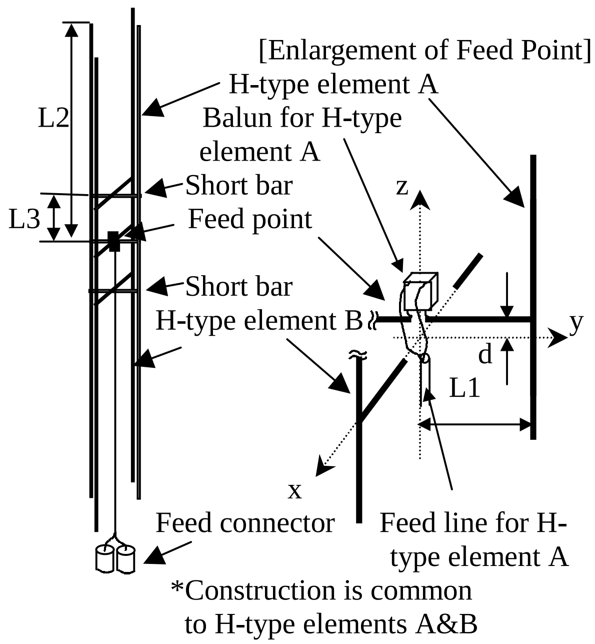

Fig.5:Configuration of prototype antenna

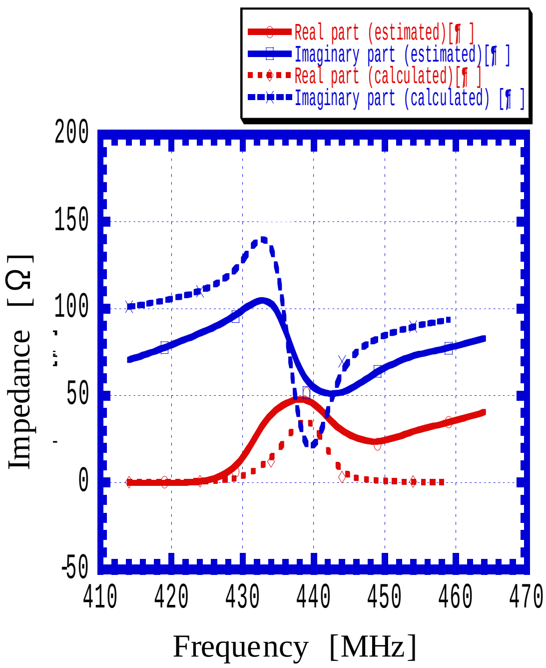

Fig.6: Impedance characteristics