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MODIFIED CIRCULAR PATCH ANTENNA

S. Dey, C. K. Aanandan, P. Mohanan and K. G. Nair

Indexing terms: Antennas, Microstrip

A circular microstrip antenna with a modified structure is presented. By adjusting the feed location along the circumference of the patch it is possible to match the antenna with a microstrip line of any impedance. The impedance bandwidth and radiation characteristics are unaffected by this structural modification.

Introduction: Owing to their excellent properties such as light weight, conformal nature and low production cost, microstrip antennas are widely used as radiating elements in phased arrays. Commonly employed microstrip radiating elements are rectangular and circular patches [1, 2]. The advantage of the circular patch over the rectangular patch is the smallness of the area. However, the high input impedance along the circumference restricts the direct use of 50Ω microstrip line as a feed for circular patch antennas. Direct matching of a circular patch to a 50Ω feed line is possible only through a coaxial feed because the matching point always lies within the patch. This increases the fabrication cost and design complexity and makes it unsuitable for microwave integrated arrays.

In this Letter, a modified design of the circular patch rectifying the above defect is presented. A sectoral slot with a shunt element offers a wide variation in input impedance along the circumference of the patch. Thus by simply adjusting the location of the feed point, this antenna can be matched to a microstrip feed line of any impedance, as in the case of a rectangular patch, without deteriorating the radiation characteristics.

Design and experimental details: The schematic diagram of the proposed microstrip antenna configuration is shown in Fig. 1. A sectoral slot is cut on the circular patch and the slot is shunted by a conducting strip, which acts as a perturbing element and modifies the current distribution on the patch surface. The location of the feed is specified in terms of angle ϕ with respect to the centre of the slot.

The antenna is fabricated on a dielectric substrate having thickness $h = 0{\cdot}16$ cm and dielectric constant $\varepsilon_r = 4{\cdot}5$. The radius of the patch r is 4·95 cm and the sectoral slot angle is 6°. The position of the shunt from the centre of the circle is 2·35 cm and the width of the shunt is 0·5 cm.

The measured input impedance of the patch antenna at resonance, at various points along the circumference, is shown in Fig. 2. The variation in input impedances ranges from 36 to 99Ω and is 50Ω when the feed point corresponds to $\phi = 12°$. It is possible to obtain an input impedance of 50Ω at different values of ϕ depending on the slot angle and the shunt position. From the graph it can also be seen that there is a slight variation of ~6 MHz in resonance frequency with feed location.

The variation of input impedance along the circumference can be explained as follows. An ordinary circular patch

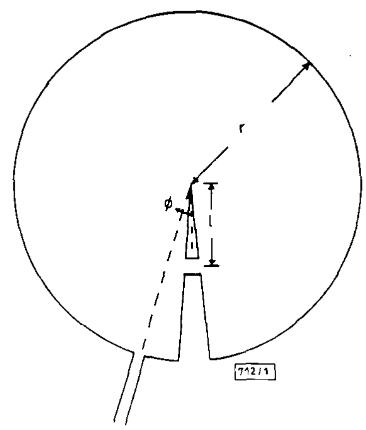

Fig. 1 *Schematic diagram of antenna*

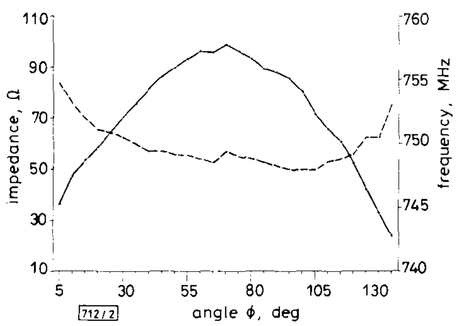

Fig. 2 *Variation of input impedance and resonance frequency with angle ϕ*

——— impedance
------- frequency

antenna is always symmetric with respect to the feed located on the circumference. Hence the impedance for the dominant mode varies only along the radius. However, in this case, owing to the slot and the shunt element, the structure is asymmetric so that the variation in impedance also depends on the position of the feed point along the circumference.

Fig. 3 shows the variation of VSWR with frequency for a 50Ω feed line with $\phi = 12°$. From the Figure, the input VSWR of the antenna at 752 MHz is 1·05. The resonance frequency for a circular patch, having the same radius, at the dominant mode is 840 MHz [3]. The decrease in resonance frequency for the new structure is due to the effective increase in cirumference of the patch due to the slot.

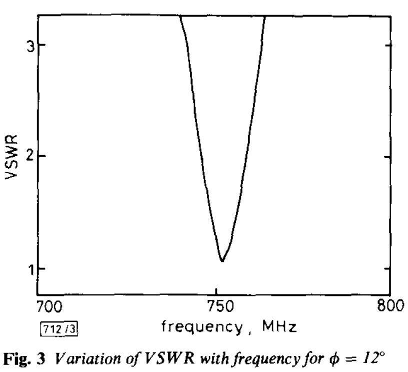

Fig. 3 *Variation of VSWR with frequency for $\phi = 12°$*

E and H-plane radiation patterns, at resonance are shown in Fig. 4*a* and *b*, respectively. As in the case of the circular

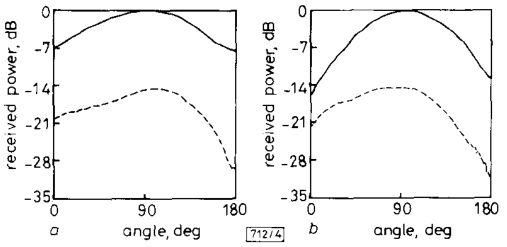

Fig. 4 *Radiation patterns*

——— copolar
– – – – crosspolar
a E-plane
b H-plane

patch, the 3 dB beamwidth of the E-plane radiation pattern is slightly more than that of the H-plane pattern. The 3 dB beamwidths of E and H-plane patterns are 100 and 85°, respectively. In both the cases, crosspolar patterns are at least 15 dB down compared to the corresponding copolar patterns. Thus, the experimental results show that there is not much deviation in the radiation characteristics of this antenna compared to the conventional circular patch antenna.

Conclusion: A modified design of a circular patch antenna, showing wide variation in input impedance along the circumference of the patch, is presented. The impedance tuning capability of the circular patch is achieved without deteriorating the antenna radiation characteristics. This antenna can be used as a radiating element in large phased arrays implementing a corporate feeding structure.

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EFFECTS OF MEASUREMENT SAMPLE AVERAGING ON PERFORMANCE OF GSM HANDOVER ALGORITHM

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Indexing terms: Mobile radio systems, Algorithms

The performance of the GSM handover algorithm is investigated with respect to signal strength measurement sample averaging. It is shown that the averaging time and the handover margin are closely linked, and have to be considered jointly in setting the parameter values of the handover algorithm for the elimination of inappropriate handovers.

Introduction: In the GSM cellular mobile system the handover process is identified as a combined operation of the mobile station (MS), base station (BS), and the mobile switching centre (MSC). Although it does not make it mandatory, the GSM recommendation states that the initial assessment of the measurements, in conjunction with defined thresholds and handover strategy, are to be performed in the BS. For this purpose, the BS receives regular measurement reports sent by the MS which carry the downlink performance. Among these measurements, by far the most important is the received signal strength at the MS. While in active mode the MS measures the downlink signal strength of the serving BS as well as those of neighbouring BSs. Intercell handover will normally take place when it is found that the MS can communicate with a neighbouring BS at a lower power level than it does with the serving BS. The serving BS continuously monitors the movement of the MS by keeping a list of candidate cells to which the MS could be handed over. Cells in this list are ranked according to the signal strength reported by the MS.

This process, however, has to deal with the fact that the signal strengths received by the MS along its path do not follow smooth variations. Although the primary criterion determining signal strength at a given position is distance from the BS, the terrain and the built up environment cause rugged and unpredictable variations in signal strength. Near the cell boundaries these variations could trigger unnecessary handover requests, causing degradation in the system performance.

To circumvent this, GSM recommends that the reported signal strength (by the MS) be the average of the received signal strength measurement samples. While the averaging process reduces the unevenness of the signal strength profile, it also removes the sharpness of its path-loss gradient which provides vital information in determining the cell boundary for the purpose of handing over. This Letter reports the results of a study made on the effects of averaging of the measurement samples of the signal strength, its influence in eliminating unnecessary handover requests, and its impact on the handover-margin (hysteresis) setting of the handover algorithm.

System modelling and simulation: Fig. 1 shows a four-cell vicinity in which an MS is set to take a trajectory indicated by AB.

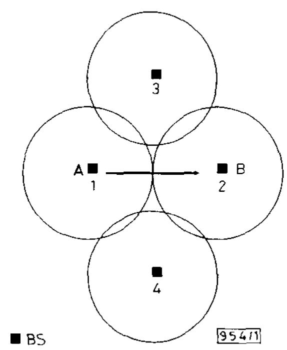

Fig. 1 *Four cell vicinity consisting of a serving cell, a target cell, and two neighbouring cells*

MS moves from A to B

Base stations in all cells are assumed to be operating at the same transmit power and without any power control. In deriving the signal strength at the MS, empirical relationships [1] have been assumed, and the path-loss component of the resulting signal has been calculated accordingly. Log-normal shadowing has been incorporated to take into account abnormalities of the terrain and the built up environment, with different variances representing the cases of light, average, and heavy shadowing [2].

In the simulation, the received signals from the four BSs are input to the GSM algorithm to determine the occurrence of handover requests as the MS moves across the cell boundaries. The signal samples received at intervals corresponding to SACCH (slow associated control channel) blocks are averaged before inputting to the algorithm. The averaging period is made an integral number of SACCH blocks. A cell radius of 10 km and a vehicle (MS) speed of 100 km/h have been