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Guidelines for Implementation of a Single Mainbeam Direction Controllable Patch Antenna Element

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Abstract

This paper briefly reviews on the possibility of the mainbeam direction controlling capability of an ideal single antenna element and a patch antenna with dielectric realised using a 2-D transmission line model. For implementing a mainbeam direction controllable patch antenna element in some applications, for example, terahertz sensing in front of the vehicles, the implemented antenna element must be integrated into an IC. For convenience, this paper provides only a guideline to design an implemented mainbeam direction controllable patch antenna element in a lower frequency range (less than 1 GHz).

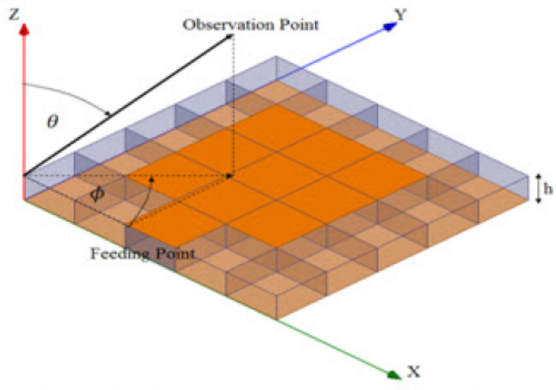

Figure 1. An ideal mainbeam direction controllable antenna element [1, 2]

1 Introduction

Kuhirun, Boonek and Silabut [1, 2] demonstrated that the mainbeam direction of an ideal patch antenna element can be controlled by manipulating the permittivity of the dielectric in between the patch and the ground. This is briefly discussed in section 1.1. Due to the fact that manipulating permittivity of the dielectric in between the patch and the ground is not possible in practice. Kuhirun, Boonek and Silabut [3] showed the evidence that mainbeam steerable patch antenna elements can be realised using 2-D transmission line models. This is briefly discussed in section 1.2. Also, this has been filed for Thai patent application [4].

1.1 An Ideal Mainbeam Direction Controllable Antenna Element

An ideal mainbeam steerable patch antenna element shown in Fig. 1 is simply a patch antenna element. Different from a conventional patch antenna element in that the permittivity distribution of the dielectric in between the patch and ground can be ideally varied so that the current distribution on the patch can be controlled. As a result, the mainbeam direction of the ideal patch antenna element can also be steered.

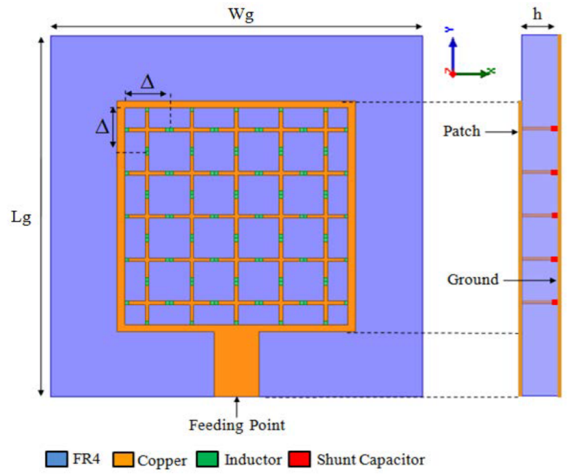

Figure 2. A realised mainbeam direction controllable patch antenna element [5]

1.2 Realisation of Mainbeam Direction Controllable Antenna Element using Transmission Line Models

As mentioned earlier, an ideal mainbeam direction controllable patch antenna element shown in Fig. 1 can be realised using a realised mainbeam direction controllable antenna element shown in Fig. 2. The reason is that the unit cell of patch, ground and dielectric in between the patch and ground can be realised using a unit cell of transmission line model. For convenience, a unit cell of 2-D transmission line model [6] consists only of series inductors and shunt capacitors embedded in conventional dielectric (FR4).

2 Guidelines for Implementation of a Mainbeam Direction Controllable Antenna Element

Consider a realised antenna element shown in Fig. 2. For convenience, suppose that all series inductors are untunable whereas shunt capacitors are tunable. Also, each shunt capacitance value can be tuned in four different values. It is tuned so that the directivity of the the mainbeam in the desired direction is maximised under the constraint that the magnitude of reflection coefficient in dB ($|\Gamma|_{dB}$) is less than a threshold value, for example, $-10dB$. The four different values can be selected using an optimization technique, for example, particle swarm optimisation [7, 8].

As mentioned earlier, for some applications such as terahertz sensing in front of vehicles, a mainbeam controllable antenna element is necessarily integrated into and IC. For convenience, this paper provide a guideline for implementing a mainbeam direction controllable patch antenna element in a lower frequency range (less than 1 GHz).

A realised antenna element shown in Fig. 2 can be implemented by an implemented mainbeam direction controllable patch antenna element shown in Fig. 3. IC (CD4066BE) [9], shown in Fig. 4, is a bilateral switch controlled by ATmega8 [10], one of 8-bit microcontrollers from Atmel.

Each IC can implement each shunt capacitor with four capacitance values, C_1, C_2, C_3 and C_4 by connecting a capacitor with a capacitance value C_1, C_2, C_3 and C_4 to SIG A IN/OUT, SIG B IN/OUT, SIG C IN/OUT and SIG D IN/OUT, respectively, and ground.Connect the grid point of each unit cell with SIG A OUT/IN, SIG B OUT/IN, SIG C OUT/IN and SIG D OUT/IN. CONTROL A, CONTROL B, CONTROL C and CONTROL D are connected to the microprocessor so that the selected capacitance value can be controlled by the microprocessor.

3 Conclusions

An ideal mainbeam direction controllable patch antenna element which can be realised by a realised mainbeam direction controllable antenna element can be implemented by an implemented mainbeam direction controllable antenna element.

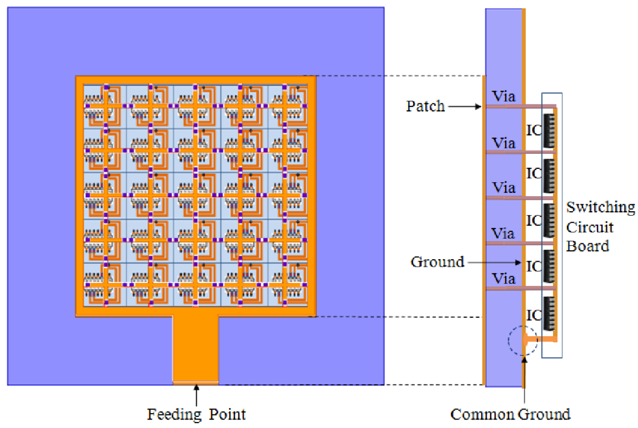

Figure 3. Implemented mainbeam direction controllable patch antenna element [5]

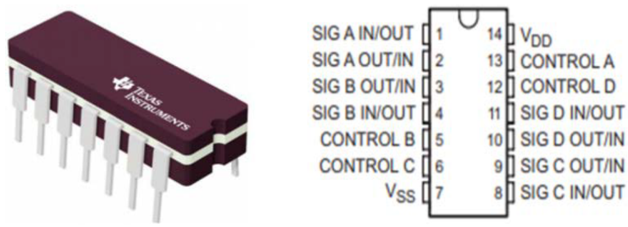

Figure 4. An integrated circuits IC (CD4066BE) [5]

4 Acknowledgements

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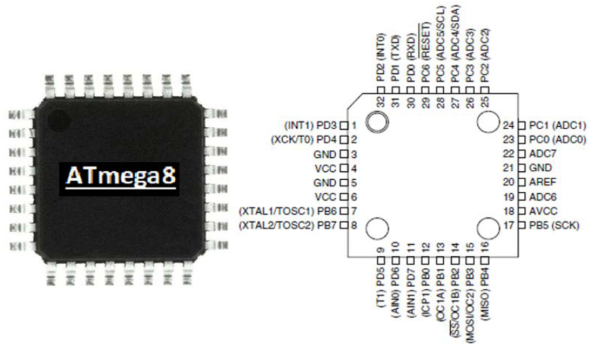

Figure 5. ATmega8, one of 8-bit microprocessors from Atmel [5]

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