# A Novel Dual - Band Notched Hexagonal Monopole Antenna for UWB Applications

B.Premalatha [1], MVS Prasad [2], MBR Murthy [3]

[1] Acharya Nagarjuna University and Faculty ECE, CMR College of Engineering & Technology, Medchal, India.
[2] ECE, RVR&JC College of Engineering, Guntur, India,
[3] ECE, Rajiv Gandhi University of Knowledge Technologies, Basara, India.

bpremalatha@cmrcet.org,mvs_prasad67@yahoo.co.in,mbrmurthy@gmail.com

***Abstract* – We propose a compact ultra-wideband (UWB) hexagonal monopole antenna with dual band-notched characteristics. The design consists of a hexagonal radiating patch and a partial ground plane. In 2002 Federal communication commission assigned a frequency band of 3.1GHz-10.6 GHz for commercial applications. Our hexagonal radiating patch has dimensions 32x22x1.57 mm$^3$ and is printed on the RT/Duroid substrate with dielectric constant 2.2. Defected ground structure is used to achieve UWB characteristics. There are existing wireless technologies that use certain bands for their operation which lie within the Ultra-wide band. To achieve high data rates of transmission and to avoid interference between the existing bands, band notching characteristics are proposed. In order to achieve dual band notching inverted U- shaped slots are embedded on the patch to reject WiMAX band from (3.3-3.8) GHz and WLAN band (5.3-5.6GHZ). The dimensions of the slots are optimized and the antenna units are simulated using High Frequency Structure Simulator (HFSS). The antenna performance parameters such as Return loss, Gain, Directivity, Radiation pattern and VSWR are measured. The simulated antenna is fabricated and tested. The results are compared and reported.**

***Keywords* - *Inverted U, Ultra-Wide band (UWB), Slots, Band notching.***

## I. INTRODUCTION

The UWB technology was originally developed during the 60's for military applications. But with Federal Communications Commission (FCC) allocating the frequency band of (3.1-10.6) GHz for commercial applications in 2002[1], work on UWB antennas gained more interest in the research community. The main reason for popularity of UWB technology is its fast data rate. With the rapid developments in the wireless communications systems (WCS), UWB have become prominent technology because of its large bandwidth and data rate [2].

There are multiple definitions for a UWB signal but Federal communication commission (FCC) defines UWB signal as a signal which meets at least one of the criteria. The 10 dB fractional bandwidth is greater than 0.20 or the 10 dB bandwidth is equal to or greater than 0.5 GHz, regardless of the fractional bandwidth [3].

There are existing wireless technologies, like Wireless Fidelity (Wi-Fi), Worldwide Interoperability for Microwave Access (WiMAX), C band downlink frequency, Wireless Local Area Network (WLAN), X Band downlink Satellite communication application, and International Telecommunication Union (ITU) band operations. They use for their operation certain frequencies within the UWB Band [3-14]. So while designing a new UWB patch antenna interference with already existing bands of wireless technologies have to be avoided. To avoid the interference with bands already in use dispensation or notching characteristics are proposed.

Several researchers worked on different shapes for patch, namely triangular, hexagonal, elliptical etc. A dual band notched hexagonal UWB monopole is developed by simulation and performance studies are carried out. The patch is fabricated and experimentally its performance is evaluated.

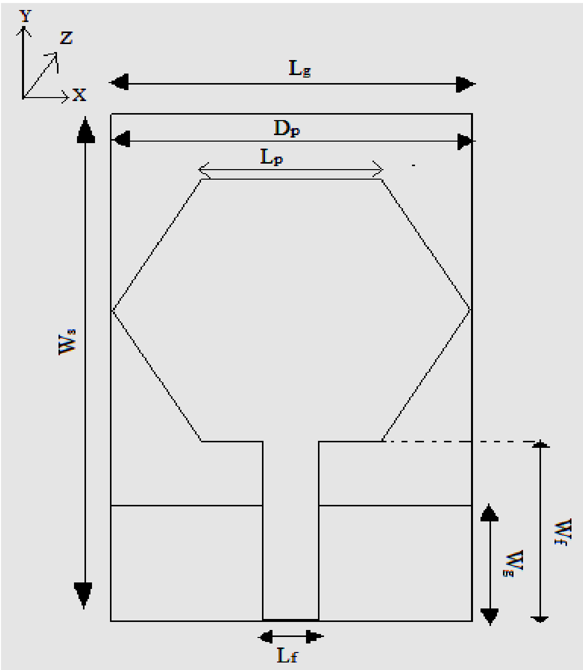


Fig 1 Structure of basic UWB hexagonal antenna

In this paper we propose the elimination of the existing bands namely (3.3-3.8) GHz for WiMAX and (5.3-5.6) GHz for WLAN bands are done. In this paper the antenna units are excited using micro strip line feeding. To achieve band notching characteristics two inverted U slots are made on patch and the effect of these slots on the performance parameters like return losses, VSWR, Radiation pattern and Gain are evaluated.

## II. ANTENNA DESIGN

Initially hexagonal UWB patch antenna is designed and the dimensions of the hexagonal patch are calculated using the design equations mentioned in literature [15]. The dimensions are mentioned in Table I.

TABLE 1: DIMENSIONS OF BASIC HEXAGONAL MONOPOLE ANTENNA

| Parameter | Dimensions in mm |
|---|---|
| Length of the ground plane (Lg) | 7 mm |
| Width of the ground plane (Wg) | 32 mm |
| Length of Substrate (Ls) | 22 mm |
| Width of Substrate (Ws) | 32 mm |
| Thickness of Substrate (h) | 1.57 mm |
| Side length of Patch (Lp) | 11 mm |
| Diameter of Patch (Dp) | 22 mm |
| Height of Patch (H) | 19 mm |
| Length of feed line (Lf) | 8 mm |
| Width of feed line (Wf) | 3 mm |
| Dielectric constant ($\varepsilon_r$) | 2.2 |

### *A. Simple UWB Hexagonal Monopole (Antenna 1)*

In this section the basic antenna covering the entire Ultra-wide band frequency from 3.1-15 GHz is first observed to get better radiation characteristics the antenna is made to use a partial ground plane (DGS). In this antenna design, hexagonal patch having radius 11 mm is taken. The length of the ground plane is affecting the performance of the antenna for design 1.The results are mentioned in Figs 2-4

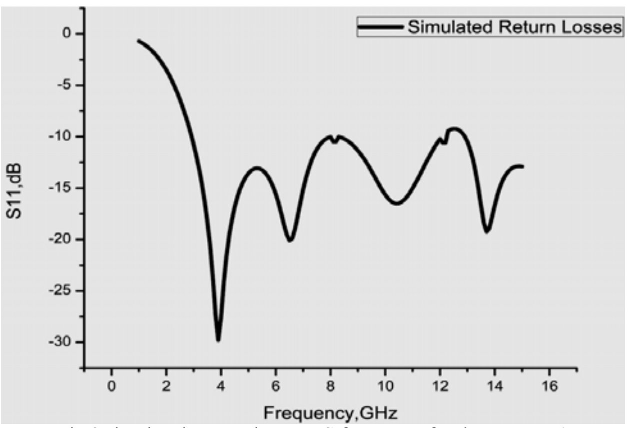


Fig 2.simulated Return losses VS frequency for the antenna 1

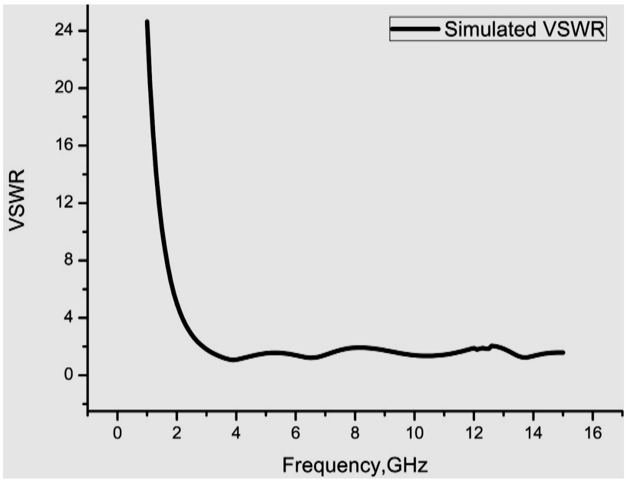


Fig3 Simulated VSWR Vs Frequency for Antenna 1.

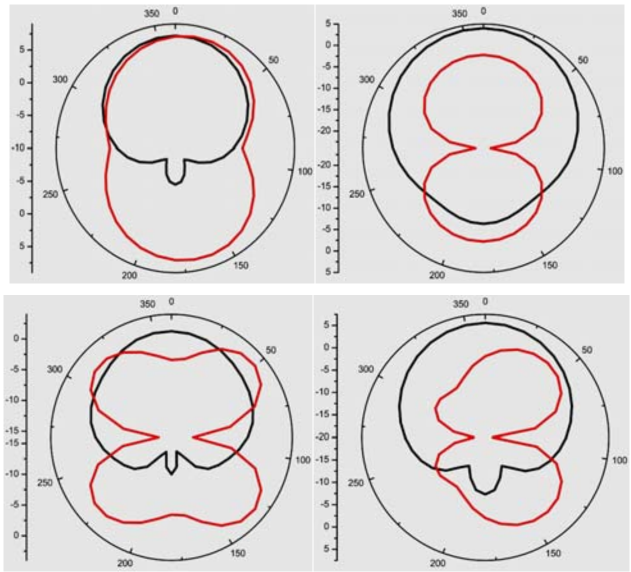

Fig 4 simulated E plane and H plane Radiation patterns at 3.1, 5, 7, 9GHz

## III. ANALYSIS OF SINGLE BAND NOTCHED ANTENNA (ANTENNA 2)

In the next step to avoid to avoid interference with the existing wireless technologies inverted U slot having dimensions mentioned in table 2 is placed on the hexagonal patch .The structure of the antenna 2 is shown in the Fig 5.This antenna is simulated using HFSS software and results are reported below.

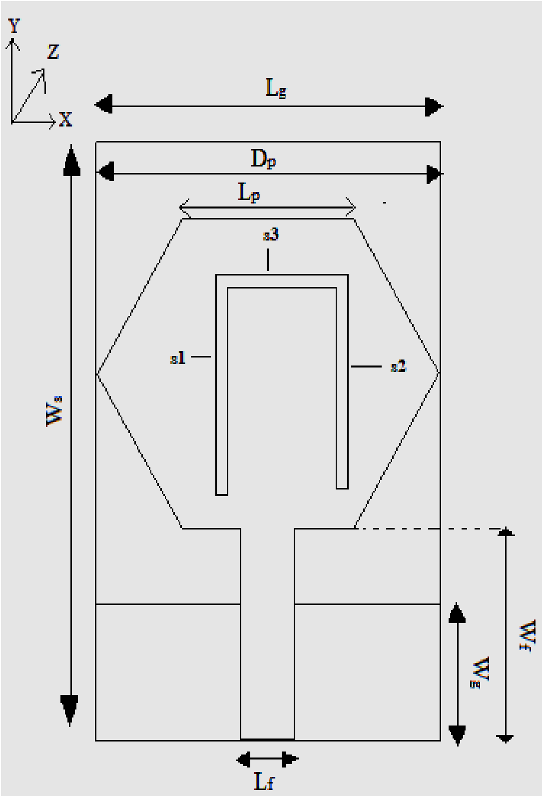


Fig 5 Structure of Antenna 2.

TABLE II. DIMENSIONS OF U SLOTS

| Name of the slot | Dimension in mm | Name of the slot | Dimension in mm |
|---|---|---|---|
| Length of S1 | 0.8 | Length of S4 | 1 |
| Width of S1 | 14 | Width of S4 | 10 |
| Length ofS2 | 1 | Length of S5 | 3.5 |
| Width of S2 | 14 | Width of slot S5 | 0.7 |
| Length of S3 | 8 | Length of S6 | 1 |
| Width of S3 | 1 | Width of S6 | 10 |

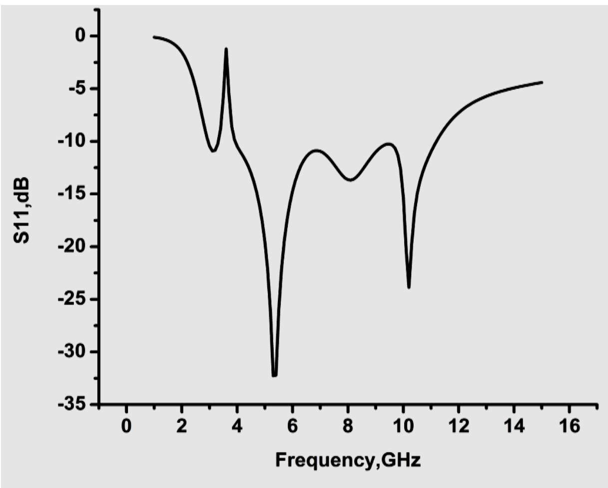


Fig 6. Simulated Return losses VS frequency for the antenna 1.

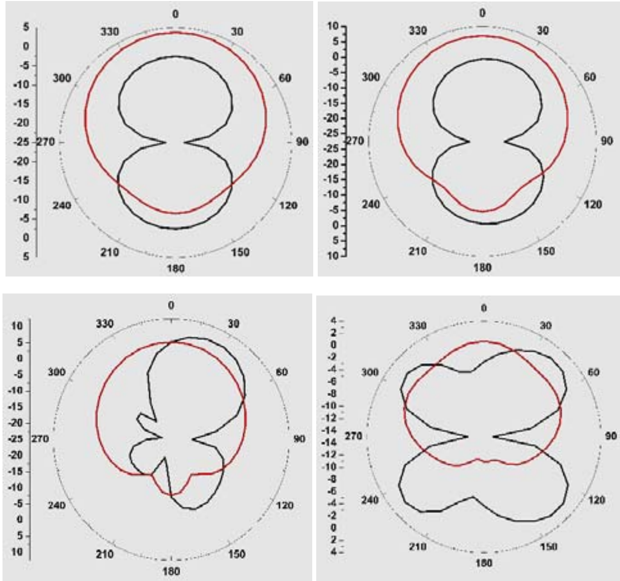

Fig 7.simulated E plane and Hplane radiation patterns at 3.1, 5.7.9 GHz for antenna 2.

## IV. ANALYSIS OF DUAL BAND NOTCHED ANTENNA (ANTENNA 3)

To avoid interference dual band rejection is proposed, in order to eliminate the existing two bands two inverted U slots are placed on the patch and the dimensions are mentioned in table II.

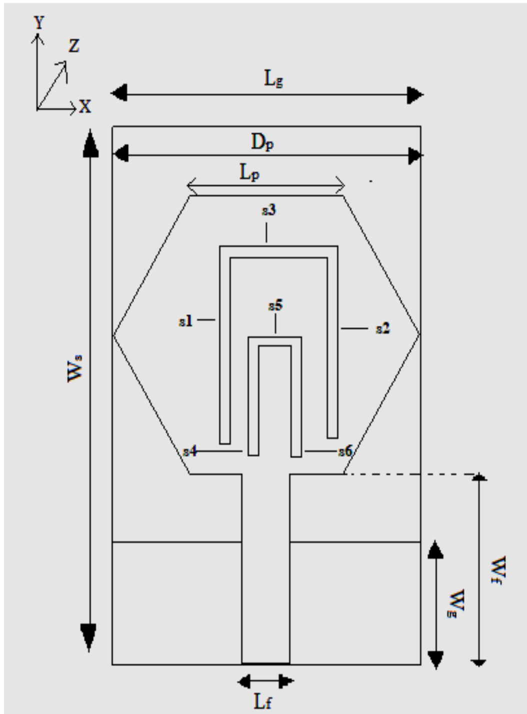


Fig 8: Structure of Design 3

Design 3 is simulated using HFSS software. The antenna is fabricated using RT/Duroid substrate material of thickness 1.57mm is used and the fabricated antenna is shown in Fig 9

Two Inverted U slots are made on the patch to obtain the notching of requisite two bands, namely (3.3-3.8) WiMAX and (5.3-5.6) GHz WLAN bands.

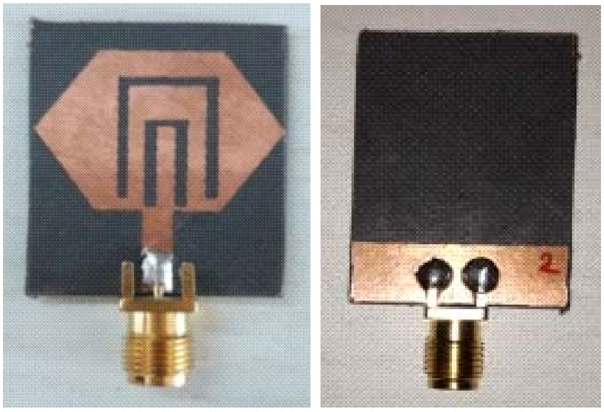

Fig 9.Fabricated dual band notched hexagonal antenna front and back view of design 3

Antenna 3 is simulated using HFSS software and this antenna is tested for return losses using AnritsMS2028C VNA Master Network analyzer. The radiation patterns are measured in anechoic chamber and the measured radiation patterns are shown in fig 10-11. Fig. 12 to 14 show the measured E plane and H plane radiation patterns at 3, 5, 7 and 9 GHz, summarized in table III.

TABLE III: SIMULATED VS MEASURED GAIN AT DIFFERENT PASS BAND FREQUENCIES FOR DESIGN 3

| Frequency in GHz | Simulated gain in dB | Measured gain in dB |
|---|---|---|
| 3 | 3.87 | 3.82 |
| 5 | 7.25 | 5.82 |
| 7 | 5.13 | 4.82 |
| 9 | 0.86 | 0.05 |

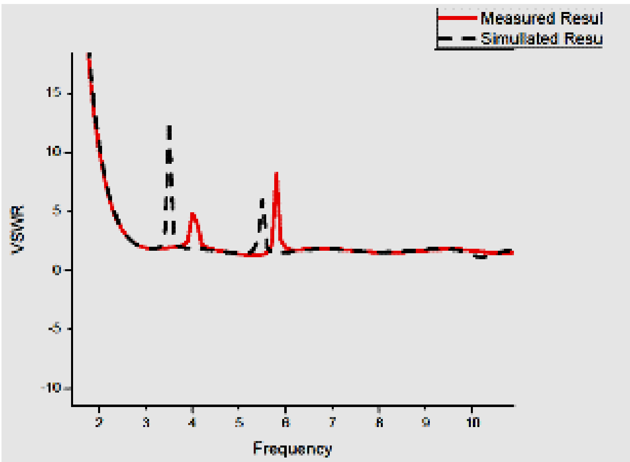


Fig 10 Simulated and measured VSWR for design 3.

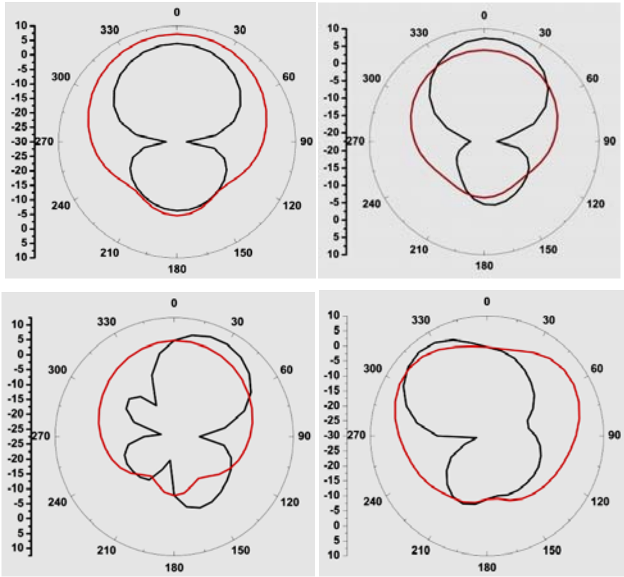

Fig11.simulated E plane and H plane radiation patterns

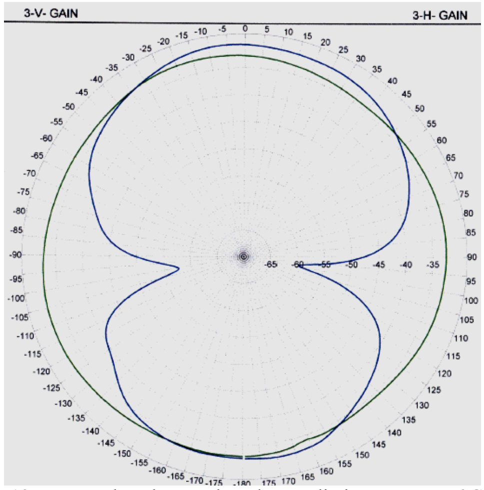


Fig 12 Measured E plane and H plane radiation pattern at 3GHz
(Project Name: Dual Band Notch Antenna, Date: 24-04-18)

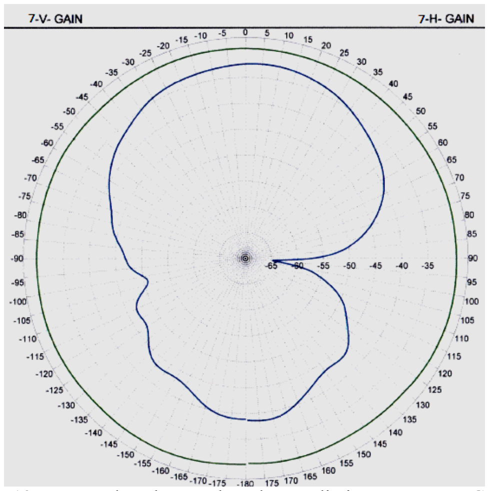


Fig 13.Measured E plane and H plane radiation pattern at 5GHz

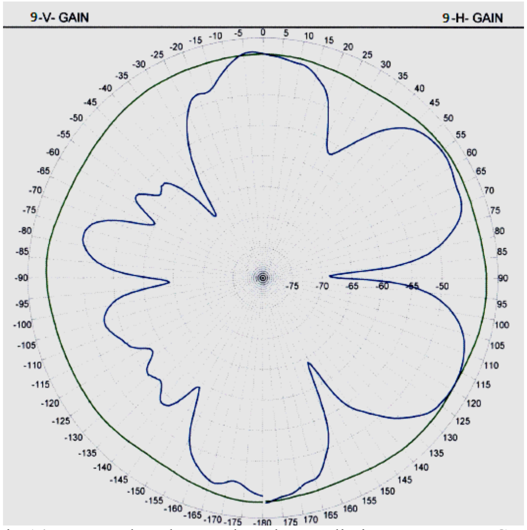

Fig 14.Measured E plane and H plane radiation patterns at 7GHz

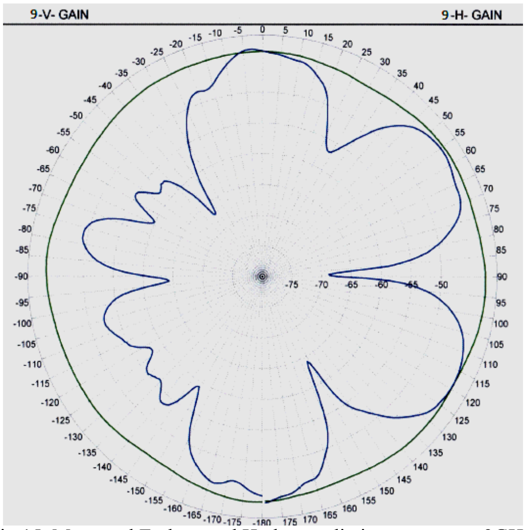

Fig 15. Measured E plane and H plane radiation patterns at 9GHz.

## V. RESULTS AND DISCUSSIONS

In this paper we designed a compact UWB antenna with a single and dual band notching characteristics, then simulated and tested it. The basic UWB antenna (Design 1) operates in the frequency band from 3.1 to 15GHz. To avoid interference, first a single band notch antenna (Design 2) is designed and simulated. The single band notch antenna was able to eliminate the existing WiMAX band and the radiation patterns are Omni directional. Then a dual band notch antenna with two inverted U slots (Design 3) was designed, simulated and tested. The simulated and tested results are almost in line. The gain of the antenna in different pass bands is compared and the maximum gain of 5.82dB observed at 5 GHz frequency. The gain is positive in the pass band. The antennas mentioned in the literature [3-15] had a simulated gain varying from 1 to 5.5 dB in the pass band, whereas our proposed antenna gave a simulated gain of 7.25dB at 5 GHz during simulation. The simulated and measured values are almost in line.

## VI. CONCLUSIONS AND FUTURE WORK

A compact Dual band notch antenna is designed simulated and tested and the antenna is suitable for UWB applications. The proposed antennas are giving better gain in pass band and less gain in notch bands. The antenna is able to eliminate the existing wireless technologies which lie with in UWB in order to reduce interference.

For future work, a compact UWB antenna with more notching bands can be designed using new materials.

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