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NOVEL INSULATED MONOPOLE ANTENNA WITH CAP AND BALUN FOR CONFINED HYPERTHERMIA

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Abstract

An insulated monopole antenna having a balun and a cap at the coaxial feeder and the monopole end, respectively, may be designed to have a well-confined uniform heating pattern as well as the satisfactory impedance matching at the input port of the antenna. Measurements by using the infra red camera in the biologically equivalent tissue phantom shows that the highest temperature is 46 degree in centigrade at the 20 watts input power for 2 minutes and input reflection less than -30 dB at 2450 MHz.

I. Introduction

Interstitial monopole antenna has been used [1, 2] for microwave hyperthermia. The better-confined microwave power is needed for stable temperature gradient and the better impedance matching between the power generator and the antenna for the higher input microwave power. Conventional coaxially fed monopole antenna shows a rather strong field distribution near the feeder point since the currents induced on the outer skin of the outer conductor of the coaxial feeder is quite high. In order to stop the flow of this induced currents on the outer skin of the coaxial feeder, the use of balun[3] is well known. A capped monopole is known also [4] to give the shorter monopole length less than quarter wavelength due to the big end capacitance of the cap.

It is proposed and shown here that the proper choice of the position of the balun and the length of the cap gives the impedance matching between the power generator and the antenna just like the

double stub matching and the well confined and almost uniform field pattern along the monopole antenna between the cap and the balun so that it drastically improves the temperature gradient pattern.

Interstitial microwave antennas are especially suitable for inducing hyperthermia of deep-seated tumors (e.g. certain brain tumors), since stable temperature gradient from the experimental results can be expected. The plastic catheters used in interstitial combination therapy (radiotherapy/ hyperthermia) can be used to accommodation both, e.g. radioactive iodine seeds and microwave antennas. Many studies have been published on interstitial microwave antennas [1]-[9] but none of the resulting design is directly applicable to catheter ablation of the large target tumor (e.g. brain tumors or liver tumors) because the energy concentration is not so desirable in target tumor and the effective area for the treatment of tumor is small [4]. Also, as some of interstitial antennas were designed with optimization [7] or not exact design method [2], match between power generator and antennas is poor [2],[4].

II. Design, Fabrication and Measurements

In this paper, A novel balun type of microwave interstitial antennas are proposed and designed, so that high energy concentration in the target volume can be produced for as little damage as possible to the healthy surrounding tissue. Using the designed novel antennas, near field patterns and matching characteristics in muscle phantom tissue 10cm x 10cm x 10cm, SAR (specific absorption rate) pattern in muscle phantom tissue 10cm x 10cm x 10cm, temperature variation versus power in muscle phantom tissue 8 cm x 8 cm x 7 cm are measured.2.1 OBP 탑재 위성 B-ISDN 기본 구조

For proper choice of parameters like the location of the balun, the capacitive load cap length, the length of the monopole, and the thickness of the insulating teflon coating, a commercially available simulation tool, HFSS from Hewlett-Packard is used. One example of such a design is shown in Fig. 1. Calculated E-plane pattern very near to the outer conductor (5, 7, and 9 millimeters from the center) is well confined at the midpoint of the monopole and has a negligible peak at the balun(4.4 millimeters from the feeding point), as shown in Fig. 2.

The measured specific absorption rate (SAR) patterns of this balun-capped monopole ant-ennas (with two different coaxial feeders) are compared with that of a typical monopole antenna is shown in Fig. 3. The measured reflection coefficient, the peak temperature versus the input power, and the three dimensional thermal distribution are measured and shown in Figs. 4, 5, and 6, respectively.

III. Conclusion

A novel capped monopole having a balun on the outer conductor of the coaxial feeder is proposed for the interstitial microwave hyperthermia. The better confined and uniform heating pattern and the better impedance matching at the input port less than 30 dB are obtained from this antenna.

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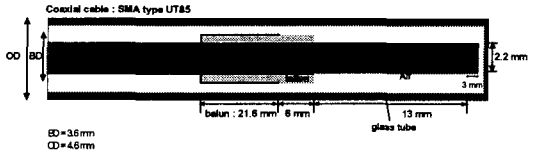


Fig. 1 Novel balun type antenna with a capped monopole

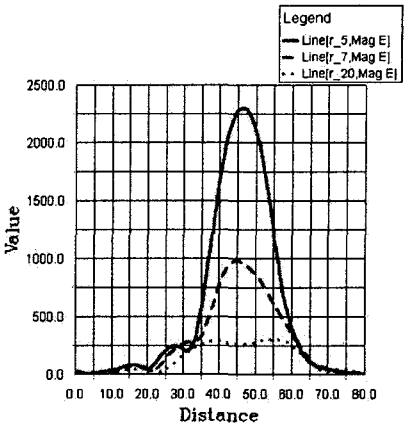


Fig. 2 Near field E-pattern (5 mm, 7mm, 20 mm from the coaxial axis) in the brain phantom.

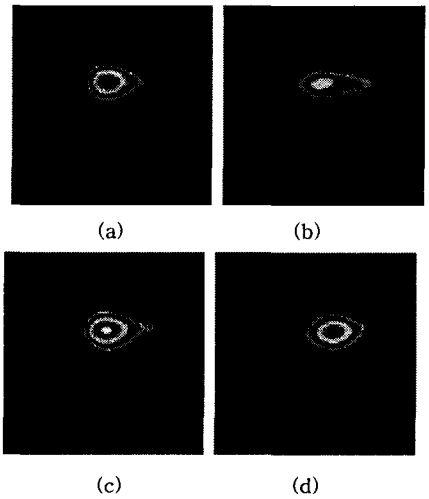


Fig. 3 SAR pattern of antenna: (a) novel balun type antenna, (SMA, UT85 cable), (b) typical Quarter-wave monopole antenna, (SMA,UT47), (c) novel balun type antenna, (SMA,UT47), (d) novel balun type antenna with tuner matching, (SMA,UT85)

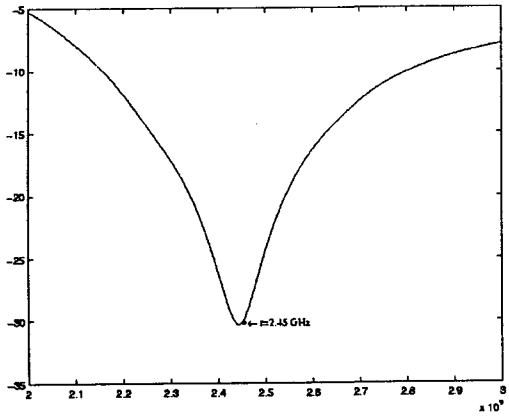


Fig. 4 Measured S11 of balun type antenna in the muscle phantom,(UT85)

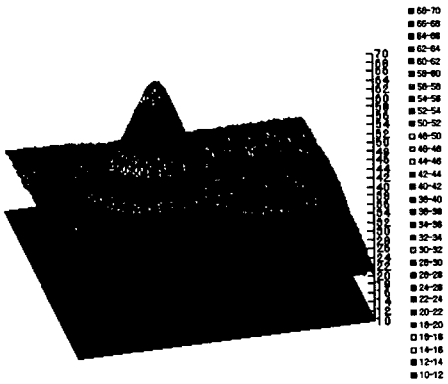
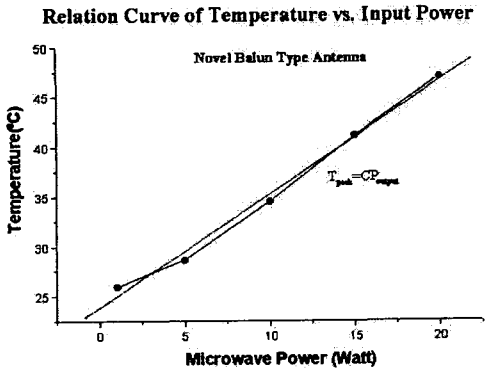
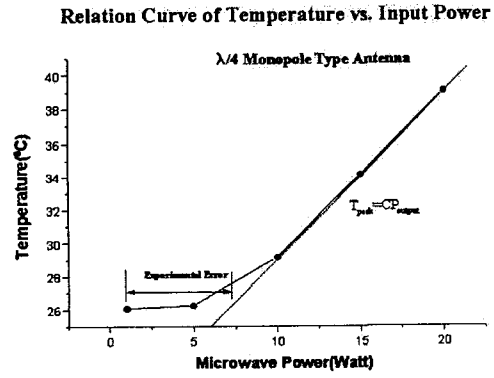


Fig. 6 3D thermal distribution of balun type antenna.



(a)



(b)

Fig. 5 Relation curve of temperature vs. input power:

(a) Novel balun type antenna,

(b) Quarter-wave monopole antenna.