Conical NMHA Design Model Using Firefly Optimisation Technique

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A conical normal mode helical antenna (NMHA) element is modelled and optimised using Firefly (FF) optimisation method developed previously by the present authors [1-2]. It is attended to have a reduced antenna height, Omni-directional radiation pattern, and possible acceptable bandwidth to operate on WLAN. The helix antenna needs to be resonated at the 2.45 GHz operating frequency. The helix is mounted on a perfect ground plane with the required bounded elements given in Table 1 and its estimated antenna geometry is shown in Figure 1. The elements of the helix considered in the optimization process are height, wire radius, helix radius at the bottom, helix radius at the top and spacing between turns of helix antenna. In addition and due to the size of this antenna is small compared to the free space wavelength another two parameters in terms of simple first order LC circuits were used to improve the input return loss. The fitness function covers 80 MHz bandwidth as constraint limit including acceptable power gain better than 0dBs. The fitness function is given by:

$$fitness_{\min} = \sum_{i=1}^{n_f}\left[w_1\left\{\left|\frac{R(\omega_i)-Z_o}{Z_o}\right| + \left|\frac{X(\omega_i)}{Z_o}\right|\right\} + w2\left|\frac{G(\omega_i)-1}{1.0}\right|\right] \quad (1)$$

Where n_f is the number of the frequencies components used to cover the entire bandwidth. $R(\omega_i)$ and $X(\omega_i)$ are the ith resistance and reactance at the input port of the antenna. G is the maximum power gain at the azimuth plane. Z_o = 50 ohms, is the characteristic impedance. The input reflection coefficient of the optimum helix dimensions is shown in Fig. 2. It can easily observed that the bandwidth at 8dB and 10dBs return losses were around 100 and 215 MHz at the attended centre frequency. The antenna power gain was varied between 0.8 and 1.2 dB over the total 215 MHz bandwidth. The antenna radiation was almost omni-directional in the azimuth plane with mostly 0.6 dB absolute variation over the 360 degrees. The variations of the fitness and accumulative functions are shown in Figs 3 and 4 for which almost the FF algorithm was capable to achieve best optimum at 10 iterations.

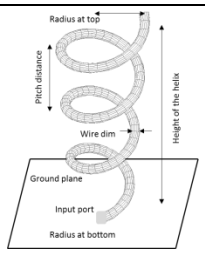

Fig. 1: The basic geometry of the helix considered in example 2

Table 2.3: The input data for the FF algorithm and the helix elements.

FF Algorithm data		Helix elements	Lower bound	Upper bound	Optimum value
Max gen.	50	Height (mm)	10	20	17.5
γ , npop	1, 30	Bottom radius (mm)	2	3	2.2
βmin	0.5	Top radius (mm)	2	3	2.8
α	0.5	Wire Rad (mm)	0.1	0.5	0.5
		Spacing between turns (mm)	4	8	6.4
		XL (ohms) → L (nH)	10 Ω	200 Ω	157.07 Ω → 9.82
		Xc (ohms) → C (pF)	10 Ω	200 Ω	35.76 Ω → 1.78

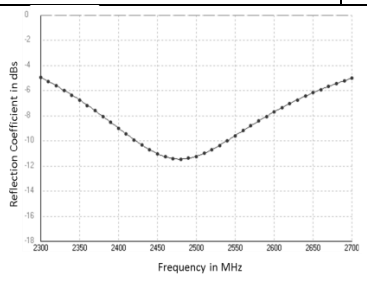

Fig. 2: Input reflection coefficient of the helix antenna.

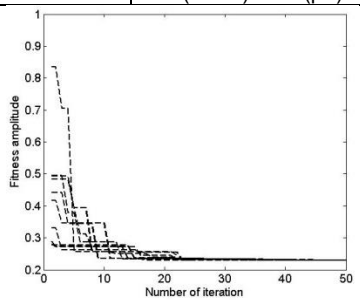

Fig. 3: The fitness variations for 10 attempts.

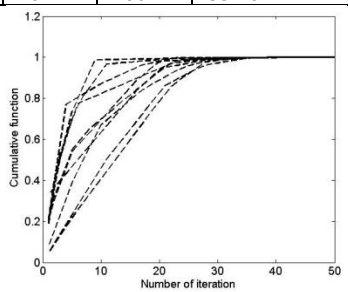

Fig. 4: The variations of CFfor FF algorithm for 10 attempts.

1. *F.M. Abdussalam, R.A. Abd-Alhameed, S.M.R. Jones, The Computation of Complex resonance of Microstrip Antenna using Method of Moment and Firefly Algorithms, LAPC 2016, Loughborough, 14-15 Nov, UK, Session 2; Paper No. 8.*
2. *H.J. Mohammed, F.M. Abdussalam, R.A. Abd-Alhameed, J.M. Noras, Evaluation of Genetic Algorithms, Particle Swarm Optimisation, and Firefly Algorithms in Antenna Design, 13th Int. Conf. (SMACD 2016) on 27th to the 30th of June 2016, Lisbon, Portugal, pp. 1-4, 2016.*