Characterizing bazooka baluns

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Audience. RF engineers and scientists working on MR hardware development

Introduction. Baluns are used to suppress common mode currents (CMC) on the outer shield of coaxial cables that connect coils and different hardware components of the MR RF transmit / receive chain. CMC can cause a) reduction in signal to noise ratio (SNR)[1], b) unwanted coupling between receive coil elements in receive arrays[1,2], and c) interactions between cables and RF transmit fields, that may increase RF safety risks [3]. Proper design and placement of baluns along RF coaxial cables is crucial for optimum RF hardware performance[1,3]. Here, we demonstrate a method to model and determine the tuning frequency and impedance of bazooka balun sections. Analytical calculations are confirmed by experimental results over a frequency range from 50MHz up to at least 150MHz.

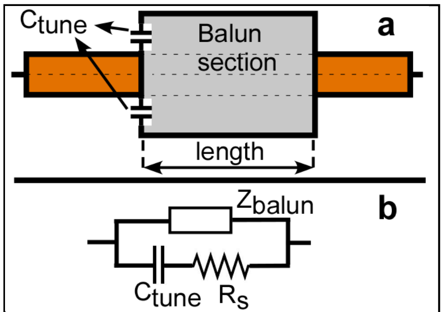

Fig. 1. **(a)** Schematic and **(b)** circuit diagram of bazooka balun.

Methods. Two bazooka baluns with lengths of 4.9 and 6.7cm are constructed on 15cm long sections of UT250 semi-rigid coaxial cables having outer diameter of 6.35mm. Polyethylene hollow cylindrical tubes (ε=2.3) with outer diameter of 19.1mm are placed on the coaxial cable and covered with a flexible double-sided copper sheet with 4oz of copper thickness in total. One end of the copper sheet is soldered to the coaxial cable while tuning capacitors are placed at the other end (Fig. 1.a). The tuning frequency and S21 of the baluns are measured using an HP 4195A network analyzer with an in-house built measurement structure (Fig. 2). To reduce coupling between the balun and the measurement structure, two ferrite cores are placed on the cables of the measurement structure. The network analyzer is calibrated by shorting the exposed inner conductors of the measurement structure with a 15cm-long UT250 cable section.

The balun is modeled as a parallel resonance circuit (Fig. 1.b). The capacitor and soldering is assumed to have a frequency independent series resistance of 0.02Ω. The complex impedance of the shorted cylinder is calculated using lossy cylindrical transmission line and impedance transformation equations[4]. The impedance is equivalent to an inductor in series with a resistance. The outer shield of the semi-rigid coaxial cable and the outermost copper sheet covering the polyethylene tubing represent the inner and outer conductors respectively. Tuning frequency, impedance and S21 of the baluns are calculated using Matlab for various tuning capacitance values.

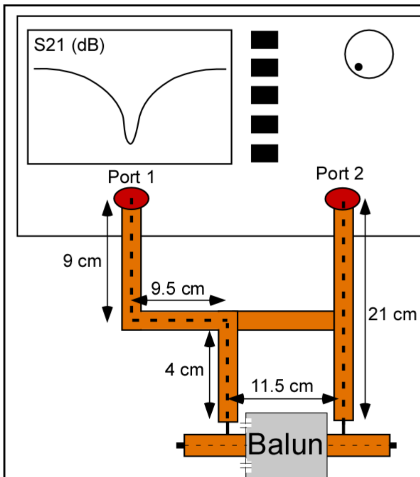

Fig. 2. Bench measurement setup.

Results & Discussion. Impedance calculations and measurements match closely below 150MHz (Fig. 3.a). The tuning frequencies of the baluns are accurately determined up to ~250MHz (Fig. 3.b). Impedances of the baluns vary from ~1 to 5kΩ. Above 150MHz possible interaction of the balun and cable with the measurement structure due to decreased wavelength may cause deviations in S21 measurements which can be alleviated by decreasing the dimensions of the measurement structure and balun. A more accurate frequency depending modeling of capacitors may also improve the results. However, the tuning frequency of the balun can still be accurately determined using this setup up to ~250MHz.

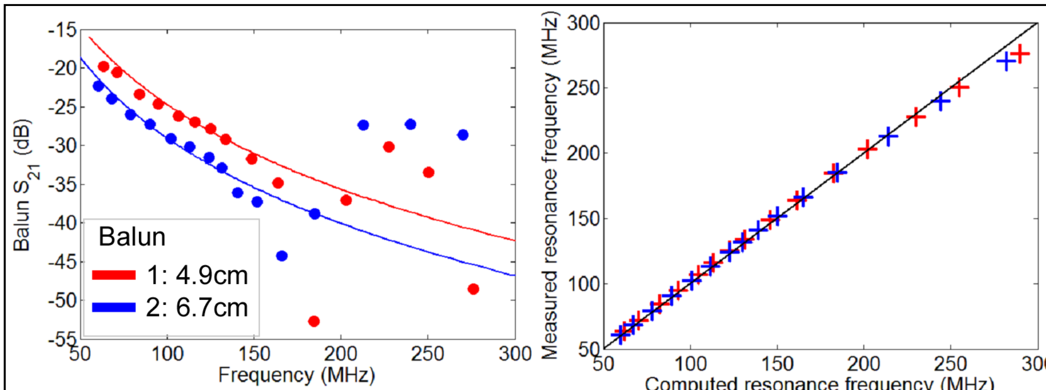

Fig. 3. **(a)** Computed (solid line) and measured (dots) S21 of the baluns. (b) Computed and measured resonance frequencies of the baluns for different tuning capacitance values.

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References. **1.** Peterson et al. Conc in Magn Res Part B: Magn Res Eng, 2003; 19B(1):1–8. **2.** De Zanche et al. NMR Biomed. 2008; 21:644–654. **3.** Seeber D et al. ISMRM (2003) p2377. **4.** Hayt and Buck, Engineering Electromagnetics, McGrawHill 2000, p439-444.