Evaluation of capacitive and transformer decoupling methods using in non-overlapped array at 7.0T

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Introduction A phased array coil had been widely used more than 10 years, the coil engineers had introduced various decoupling methods to obtain isolation between nearest elements. Overlapped phased array coil has advantages that mutual inductance between nearest coil elements could be minimized [1]. Especially, non-overlapped phased array coil requires various decoupling methods and theoretical analysis of decoupling theory also has been studied [3]. Current researches have been conducted in both simulation and experimentally for numerically comparison of decoupling methods. Volkan E. A. demonstrated simulation comparison of various decupling methods with S_{21}, the measurement of isolation with two elements, using HFSS [4], and the transformer decoupling was also compared by signal-to-noise ratio (SNR) with gapped and overlapped geometries in 3T [5]. We have conducted research on comparison between capacitive decoupling network and transformer decoupling with hybrid version of two methods in terms of SNR and noise correlation matrix on 7T.

Methods The coils are tested on a prototype 7 T human scanner (Siemens Medical Solutions, Erlangen, Germany). All coils were designed on elliptical acryl former, which is based on 250 mm diameter cylinder with longitudinally extended for human head. These coils were matched to 50 Ω loaded with a $NiSO_4$ cylindrical phantom (Erlangen, Siemens). Each element used 5 mm copper strip forming a rectangular with lateral and longitudinal lengths of 85 mm and 200 mm, respectively. Capacitors are equally distributed and additional decoupling capacitors are added between nearest elements to reduce cross-talk in capacitive decoupling [6]. Transformer decoupling method was implemented by adding wounded coils in a mirror direction which causes the linked flux to cancel their linked between nearest arrays [7]. A pair of transformers was located remotely, thus additional transformer pair was needed to further enhance decoupling performance (Fig.1). In terms of hybrid decoupling, we mainly obtained isolation with capacitive decoupling, but only two gaps were implemented with transformer method (Fig.2). The main reason for hybrid decoupling coil designed is that we afraid too many transfomers added in loop may reduce the SNR by increasing coil resistances. S-parameters were measured by network analyzer (8753ES, Agilent) to observe matched condition in desired frequency with both near and remote elements. The noise only data is acquired to see noise correlation matrix by setting the voltage to 0. The phantom image was compared by gradient echo sequence (TR=200ms, TE= 4.07ms, Flip Angle = 20° ,slice=3mm) and reconstructed with SNR unit using noise information [8].

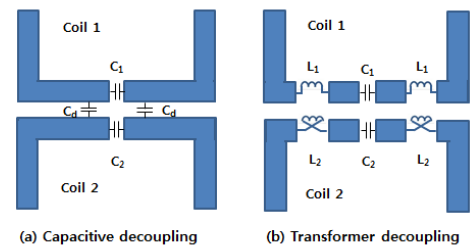

Fig 1. Equivalent circuit of decoupling method

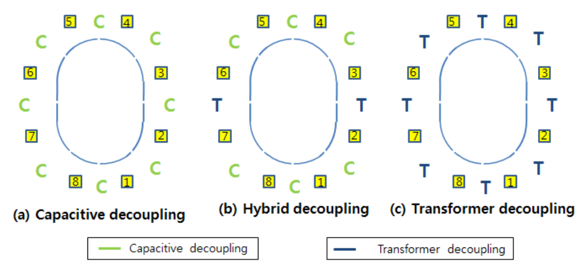

Fig 2. Coil configuration with decoupling methods

Results The capacitive decoupling has shown the highest SNR result among three types of coils both central and peripheral region (Fig.3). Especially peripheral region shows more than 15% higher SNR. In terms of S-Parameter, capacitive decoupling showed promising performance between nearest elements, but transformer decoupling provides sufficient isolation from next nearest elements. Nevertheless, ideally S-parameter has been known that it is not proportional to the SNR [9]. Noise correlation matrix is calculated with noise only data, coil elements with not sufficient isolation revealed some correlation with noise correlation matrix. Minimum reference transmit voltage also required in case of coil designed with capacitive decoupling method (Table 1).

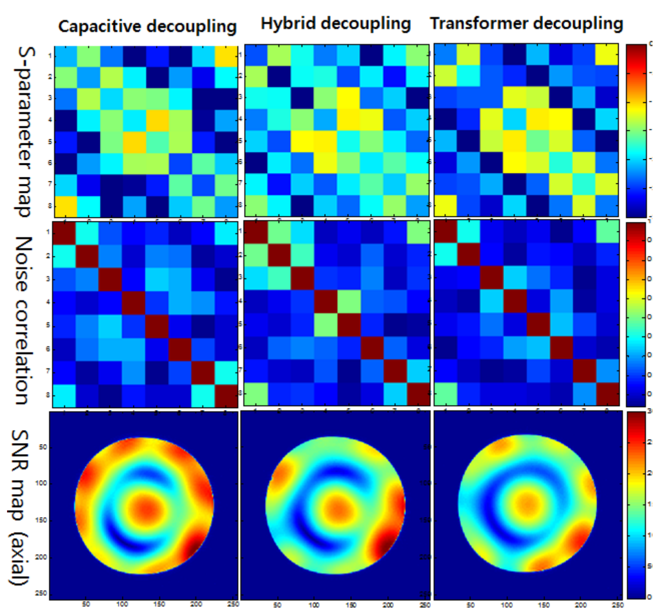

Fig 3. Result (S-Parameter map, Noise correlation, and SNR)

	Capacitive decoupling	Hybrid decoupling	Transformer decoupling
Ref. Transmit voltage	249.3V	257.1V	264.2V

Table 1. Reference transmit voltage for three coil

Conclusion The capacitive decoupling showed the greatest performance in phantom test in terms of SNR. As additional transformers added in the circuit, we assume coil resistance increased. In order to evaluate coil resistance, Q-factor evaluation is necessary in future. Even S-parameter does not have correlation with SNR, coil with minimum cross-talk required minimum transmitting voltage to obtain same flip angle.

Discussion Use of transformer decoupling has many advantages when manufacturing it. Tuning frequency of coil is not affected by nearest element, consequently coil engineers could reduce their time to tune and match of it. Placing transformer in remote position allow users to easily obtain space between elements let coil to be detachable. In contrary to this, use of capacitive decoupling method is tedious job when it is tuning and matching since element condition is easily affected by variation of decoupling capacitance. However, stable performance seems promised with minimum signal loss when designing gapped geometry coil. Unfortunately, hybrid decoupling method did not demonstrate compensation between capacitive and transformer decoupling.

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