Dynamic disabling switch development for 7T self-shielded birdcage coil

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Synopsis

The dynamic disabling switch (DDS) was designed and developed for 7T self-shielded birdcage coil. DDS is imperative with a transmit coil to receive RF signal by receive only coils like phased array coils. The DDS was designed based on the distribution circuit made of semi-rigid coaxial cable to reduce radiation loss, which is a severe problem in high frequency.

Methods and Materials

Two designs based on distribution circuits consist of semi-rigid cables and some lumped element device were built. (Fig.1) These circuits were tuned to capacitor (C1), which is a tuning capacitor on the end ring birdcage coil.

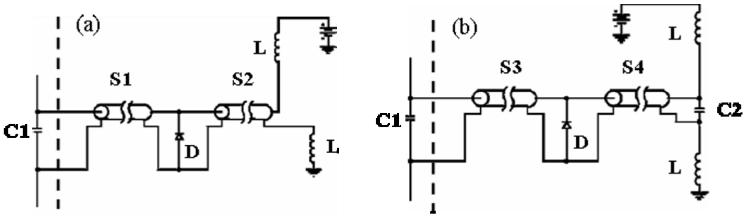

Fig.1 Circuit diagrams of dynamic disabling circuits (DDS) based on distribution circuits. *C1* is a tuning capacitor on the birdcage coil. *S1*, *S2*, *S3*, and *S4* are the semi-rigid cables. *D* is a diode for switching between enabling mode and disabling mode. *L*s are inductances to work as low pass filters. *C2* is a big capacitance for a high-pass filter.

In design (a), *S1* is λ/4 long so *C1* works as it is when diode *D* is forward-biased. *S2* length is adjusted so that *S1+S2* works as an inductance, which makes parallel resonant circuit with *C1* at the working frequency of the RF coil, when diode *D* is reverse-biased. In design (b), *S3* length is adjusted so that *S3* works as an inductance, which makes parallel resonant circuit with *C1* at the working frequency of the RF coil, when diode *D* is forward-biased. *S3+S4* is λ/4 long so *C1* works as it is when diode *D* is reverse-biased. The actual circuit were made of semi-rigid cable with 0.141 inch outer diameter. The half of the outer conductor were peeled about 5mm long at the position where a diode is soldered. The enabling capability was evaluated by measuring impedance of C1 in cases with or without a dynamic disabling circuit. The disabling capability was evaluated by measuring peak impedance and Q value of the parallel resonant circuit which consists of C1 and a dynamic disabling circuit. Design (a) showed good performance in both enabling and disabling capability. 16 DDSs based on design (a) were actually implemented into a 32 rung self-shielded high-pass birdcage coil.(1) DDSs were alternately connected to either end. Fig.2 shows how DDS are implemented without influence on the current distribution of birdcage coil. (2)

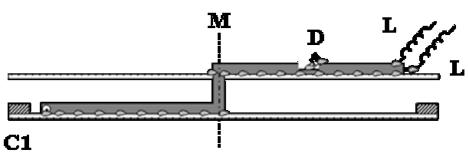

Fig.2 Implementation of DDSs into a self-shielded birdcage coil. The one end of the dynamic disabling circuit was electrically connected to an end ring capacitor in parallel. The outer conductor of the dynamic disabling circuit was electrically attached to the rung element of the birdcage coil between the end and the midpoint (M) where electric potential is ideally the same as ground. (virtual ground) Then the coaxial cable was bent by 90 degree toward the RF shield at M and was taken out of the RF shield through it. The coaxial cable was bent

Results and Discussion

The electric characteristics of the self-shielded birdcage coil were measured before and after the dynamic disabling circuits were implemented. (Fig.3) The measurements were taken with DDSs under enabling mode without load. The electric characteristics of 12cm x 12cm rectangular 7T surface coil were measured in the self-shielded birdcage coil with the dynamic disabling circuits under disabling mode. The data were compared with that in the self-shielded birdcage coil with the 16 capacitors removed where dynamic disabling circuits were supposed to be connected. (Fig.3) The Q of the birdcage coil was down by about 20% after the implementation of the dynamic disabling circuits. The ratio of Q without load to Q with human head load was around 5, so that 20% decrease wasn't thought to be so severe a problem for the performance of the birdcage coil. The Q of the 12cm x 12cm rectangular surface coil was down about 48%. On the other hand, the ratio of Q without load to Q with human head load was 23.9, so that this Q drop wasn't a big problem either. As a result, it was concluded that the built dynamic disabling circuit is applicable in practice.

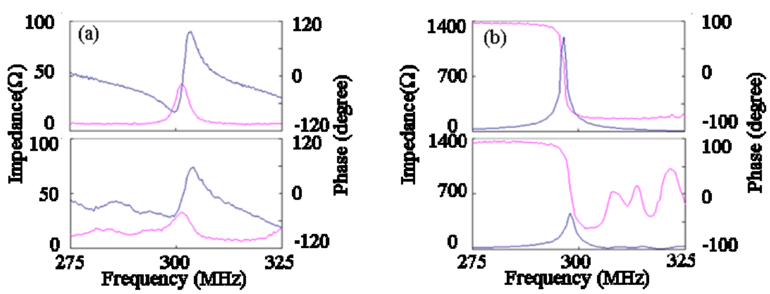

Fig.3 Electric characteristics of the birdcage coil without DDSs (upper in (a)), and with DDSs (lower in (a)) in enabling mode. Electric characteristics of 12cm x 12cm rectangular surface coil in self-shielded birdcage coil without tuning capacitors (upper in (b)) and in the self-shielded birdcage coil wirh DDSs in disabling mode (lower in (b)) Blue curves shows absolute impedances and red curves shows phases of the impedances.

References

(1) Watkins RD *et al.* Proceedings of ISMRM 2003 p.424 (2) Roemer PB *et al.* U.S. Pat 4,887,039