Hybrid decoupling for RF coils

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Introduction: In surface coil designs, it has been a common practice to decouple (detune) RF surface coils with passive decoupling circuits in addition to active decoupling circuits [1]. Both RF decoupling circuits are implemented in most receive only surface coils due to their complimentary attributes: the active circuit provides better timing control through DC biasing control in addition to its high blocking impedance while the passive one provides "self-activation" through transmit RF pulse besides easiness of its implementations, i.e., without resorting to system DC biasing control line. In this work, we pursued to combine both traditional active and passive decoupling into a new hybrid decoupling scheme and circuit; we demonstrate the mechanism of new hybrid decoupling scheme and circuit, comparison data of the traditional active and the hybrid circuit.

Method: The new circuit is designed to operate in two modes: normal and abnormal modes. In its simplest form the new circuit employs two pin diodes. The circuit is designed such that two pin diodes are connected in series DC wise but in parallel (anti-parallel) RF wise. In normal mode, two pin diodes is biased on through DC line and yields high Q RF blocking circuit, LC resonance circuit. Compared to traditional active decoupling circuit where only one pin diode is employed, the extra pin diode in the hybrid circuit effectively reduces the RF resistance of pin diode(s) by half and hence provides higher blocking impedance and generate less RF heating due to transmit RF pulses. In abnormal mode (when there is DC bias failure) each pin diode will be turned on by transmit RF pulses respectively in each half of the transmit cycle to generate a RF blocking circuit. Therefore, it will prevent RF coil damages as well as potential patient injuries due to transmit RF stress in case of DC line failures.

Results and Discussions: In normal operating mode (with DC biasing), the blocking impedances and the temperature rises due to RF heating of the conventional active blocking and new hybrid blocking circuits were measured for comparison. The same LC components were used for the measurement of the blocking impedance. The measured impedance of the hybrid circuit is 19% higher than that of conventional active one, which is very close to the calculated result: impedance of the hybrid is 20% higher than that of conventional active one as shown in Table1. Both traditional active and hybrid blocking circuits were integrated into the same testing loop coil respectively for heating test. Both of them were in the same location on the coil; and extra care was taken to ensure that the coil was in the same position between different scans to avoid RF stress variations due to environmental, such as, position-related B-field and E-field differences. The heat test was conducted with standard GE heat test protocol. The temperature rise on the surface of the inductor from the hybrid decoupling circuit was 1.5 degrees less than the conventional active one, as shown in Figure1. In abnormal mode (without DC biasing), the hybrid circuit and traditional passive decoupling circuit were integrated into the same testing coil respectively without DC biasing for comparison. In both testing setups the same B1 distortions and the system transmit gain (TG) were observed, which indicated the equivalent performance of traditional passive and hybrid decoupling circuits during transmit.

Conclusions: Compared to a conventional active decoupling circuit, the hybrid decoupling circuit provides better blocking impedance and generate less heating due to RF stress when proper biased. Without DC biasing, the hybrid circuit acts like a conventional passive decoupling circuit. It would be beneficial to further study the blocking impedance and switching time of the hybrid blocking circuit without DC biasing, i.e., in abnormal mode.

References: [1] Edelstein, U.S. Pat. No. 4620155.

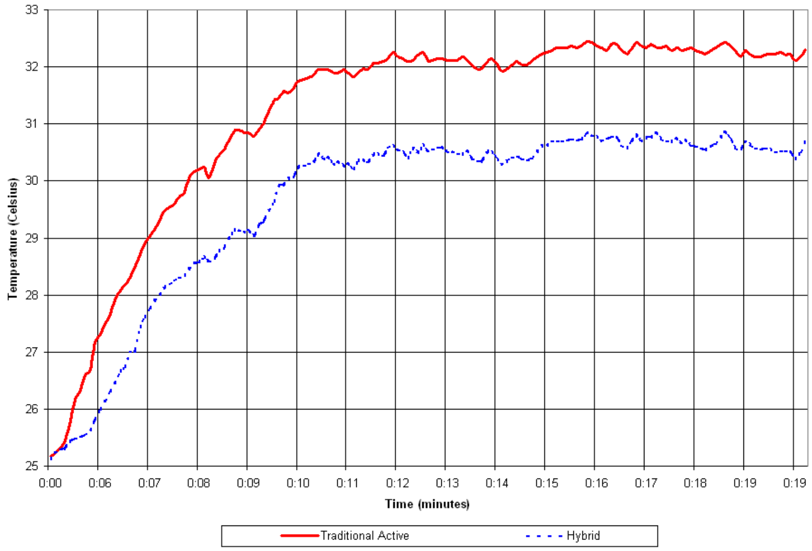

Figure 1 - Temperature rise on the inductor in decoupling circuits.

Table 1 – Impedance comparison (hybrid and conventional active with DC biasing).

BLOCKING IMPEDANCE	ACTIVE DECOUPLING WITH DC BIAS ON	HYBRID DECOUPLING WITH DC BIAS ON
CALCULATED (KΩ)	*3.24*	*3.91*
MEASURED (KΩ)	*2.7*	*3.2*