298MHz Micro miniature 2KW Transmit Receive Switch for 7.0 Tesla TR Arrays

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Introduction: TR switches serve several functions. They switch the coil elements between the RF Transmit amplifier and the receive preamplifier as well as protect the delicate preamp from damage during Transmit and isolate any noise from the transmit amplifier during receive. In recent times coil element counts have dramatically increased and many coil designs exist that use as many as 32 elements or more in both transmit and receive mode. To preserve SNR it is desirable to have the TR switch and preamplifier as close to the coil as possible. This places restrictions on the size of the TR switch and preamp assembly. In addition, to prevent B0 non uniformity, the TR switch must be very low magnetic susceptibility, since it will be in the imaging field.

Methods and Materials: A linear duplexer [1,2,3] is shown as a viable means for implementing transmit receive RF switch for MR systems. In transmit mode the diodes are on and transmit power is reflected from the RFPA to the coil and the preamp is protected. In receive mode the RFPA is isolated from the coil and the coil receive signal is split between both mid paths and recombined at the preamp port. A commercially available miniature preamp is mounted directly on the switch and connected to the receive port. Any unbalanced receive signal will be absorbed by the 50 ohm idle port. Ultra Low Magnetic Moment PIN diodes [4] are used to switch between states, and prevent magnetic artifacts in high field MR Imaging. TR switch bias can be routed into the switch on the transmit line and DC power for the preamp can be routed through the receiver line yielding 3 simple connections. Previously discussed models for PIN diodes were used to simulate the behavior of the duplexer switch [3]. The model accurately predicts the operation of the switch using industry-standard simulators such as SPICE as well as it variants.

Results: The Linear duplexer circuit is shown in Fig 1. The folded prototype switch is shown in Fig 2.
It was constructed using a pair of commercially available 90 deg hybrids (Florida RF Labs HE298MF), ultra low magnetic PIN diodes (MicroSemi UM9995), and low noise preamplifier (WanTcom WMA7RA-R5). The entire subsystem is 1" x 1" by .25". Transmit loss was -.26dB, receive isolation was -42dB, and total receive noise figure was .67dB. The switches were tested at 2KW full power.

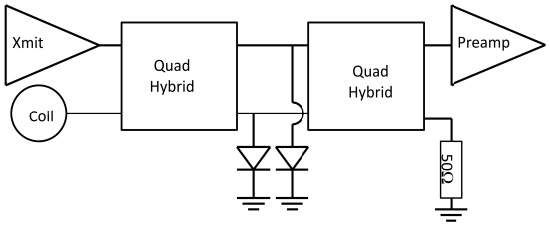

Figure1.

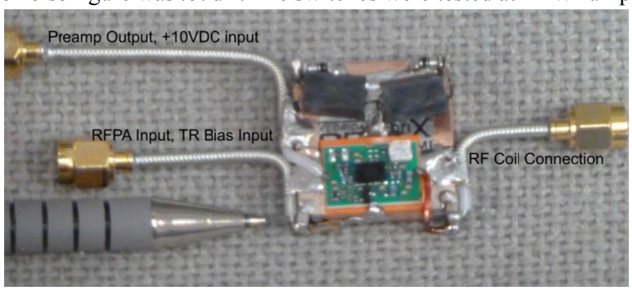

Figure2.

Discussion: This compact TR switch circuit and package has been shown to meet requirements for high element count coils designs and 3D layered package represent more than an order of magnitude of packaging size reduction. It has been constructed from low cost commercially available components. Large numbers of these subsystems can be mounted directly on the coil at Ultra High Field and support large element Arrays including parallel transmit. Further reductions in packaging size are possible.

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References:
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