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Projektarbeit

RF Coupler and Detector/Multiplexer Circuit for 7 Tesla MRI System

Description:

In our project *MRexcite* we develop a 32-channel RF transmit power amplifier array for a 7 Tesla MRI system. The design of the amplifiers includes probes which provide RF signals proportional to the currents in the MR coils (U_I) or which are proportional to the voltage at the coils (U_U). The current- signal in its original RF form is used to control the power amplifier in a feed-back loop. Both signals are used to monitor the proper operation of the amplifiers and the MR coils; for this purpose, the signals have to be down-converted to envelope voltages using logarithmic amplifiers. In order to save cabling, the two envelope signals per channel get multiplexed to one transmission line connecting to a control PC. The block diagram of the circuit shows the two input signals at RF of 300 MHz, a directional coupler splitting the current-signal into two with an attenuator leading one part to an RF output port, and a logarithmic amplifier and driver amplifier of small gain for both the current- and the voltage-signal followed by a selector switch (multiplexer, MUX) for each channel. The switch is shown to be controlled by a TTL-signal from a PC. The task of the thesis is to build such a circuit with eight channels on one printed circuit board (PCB) and using the integrated circuits as given in the diagram.
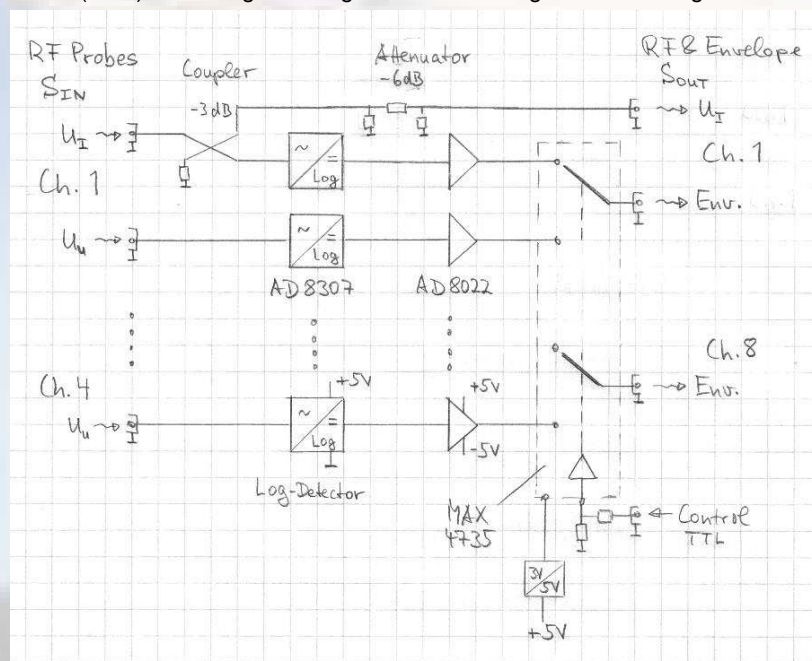
The task entails the following steps:

1. Familiarize with the function of the circuit components, in particular the ICs and the directional coupler, using the data sheets of the manufacturers.
2. Familiarize with EAGLE, the CAD tool for the design of printed circuits boards, using the EAGLE tutorial.
3. Design the circuit schematic for one channel, including all necessary SMD components for the operation of the ICs based on the examples and evaluation board proposals given in the data sheets.
4. Transfer the circuit to the board layout in EAGLE and optimize positions of components.
5. Deliver the PCB data set to the in-house PCB workshop. Assemble the ICs and SMD components to the fabricated PCB and test the functionality of the circuit. In particular:
   a. test the current consumption of the circuit and compare to the data sheet values,
   b. check the dc voltages at the power supply pins of ICs as well as at the input / output pins of ICs,
   c. apply an RF signal at the input ports and check the generated envelope signals at the logarithmic detectors, at the driver amplifiers and the switch,
   d. check the multiplexing of the switch by observing the switching delay, insertion loss and the unwanted signal coupling.
6. In case of any flaw in the circuit, redesign and repeat the production process.
7. For a flaw-less design, produce the layout for an eight-channel circuit with common power supply and switch control signal distribution to all channels.

At the end of the work, a public presentation of the work is to be given.