# Reconfigurable Electronic Tune-Detune Circuit for RF Coil Systems

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## INTRODUCTION

This paper proposes a high-speed reconfigurable (-30V/-250V) electronic circuit that enables the rapid tuning and detuning of RF coil configurations, specifically a RF volume coil capable of providing high B1 homogeneity and a RF surface coil with high local signal-to-noise ratio (SNR) that have to be operated independently in transmit and receive modes. During the transmit phase, the surface coil must be detuned to prevent damage from the strong B1 transmitted field of the volume coil. Following the transmit phase, the volume coil is then detuned and the surface coil is tuned to receive the MR signal. For most preclinical applications, the switching from the tuned to detuned states should typically occur in less than 5μs to permit the implementation of high-speed imaging.

## THEORY

The key circuit idea is based on a four MOSFET topology, see Figure 1 (a); it forms the basis of the coil switching mechanism to provide a positive voltage to forward bias the PIN diodes, or a negative voltage to reverse bias the PIN diodes of the coil's detune circuitry. A first set of P-channel and N-channel MOSFETs, M2 and M4, are used to switch between a forward bias voltage of 12V, and reverse bias voltages of either -30V for a typical surface coil or -250V for a typical volume coil. The reconfigurable topology allows the forward and reverse currents to be limited by the respective drain resistances R2 and R4. Forward and reverse currents are set to 50mA and -50mA for a typical surface coil, and 200mA and -2.5mA for a typical volume coil. In an effort to decrease the switching time, a second set of complementary MOSFETs, M1 and M3, is added to provide an approximate 5μs burst of high current during the transition time as the output switches from the tune to detune state or vice versa. Signals controlling the gates of each MOSFET are seen in Figure 1 (c).

## RESULTS AND DISCUSSION

In order to quantify the switching times and voltage waveforms, the output of the surface coil drive circuit $V_{output\ 1}$, see Figure 1 (b), is connected to a digital oscilloscope and the waveform is captured at both the rising and falling transition points, shown in simulations in Figures 1 (b), and in measurements in Figures 1 (d) and 1 (e), respectively. In Figures 1 (d) and (e), the upper trace is a simulated TTL control signal $V_{Control}$ from the console, and the lower trace is the circuit's output voltage. The output is attached to a typical surface coil load with PIN diode detune circuitry. It can be seen that the circuit switches the load in approximately 1μs. Measurements with various coils have shown typical rise and fall times of 1μs and less.

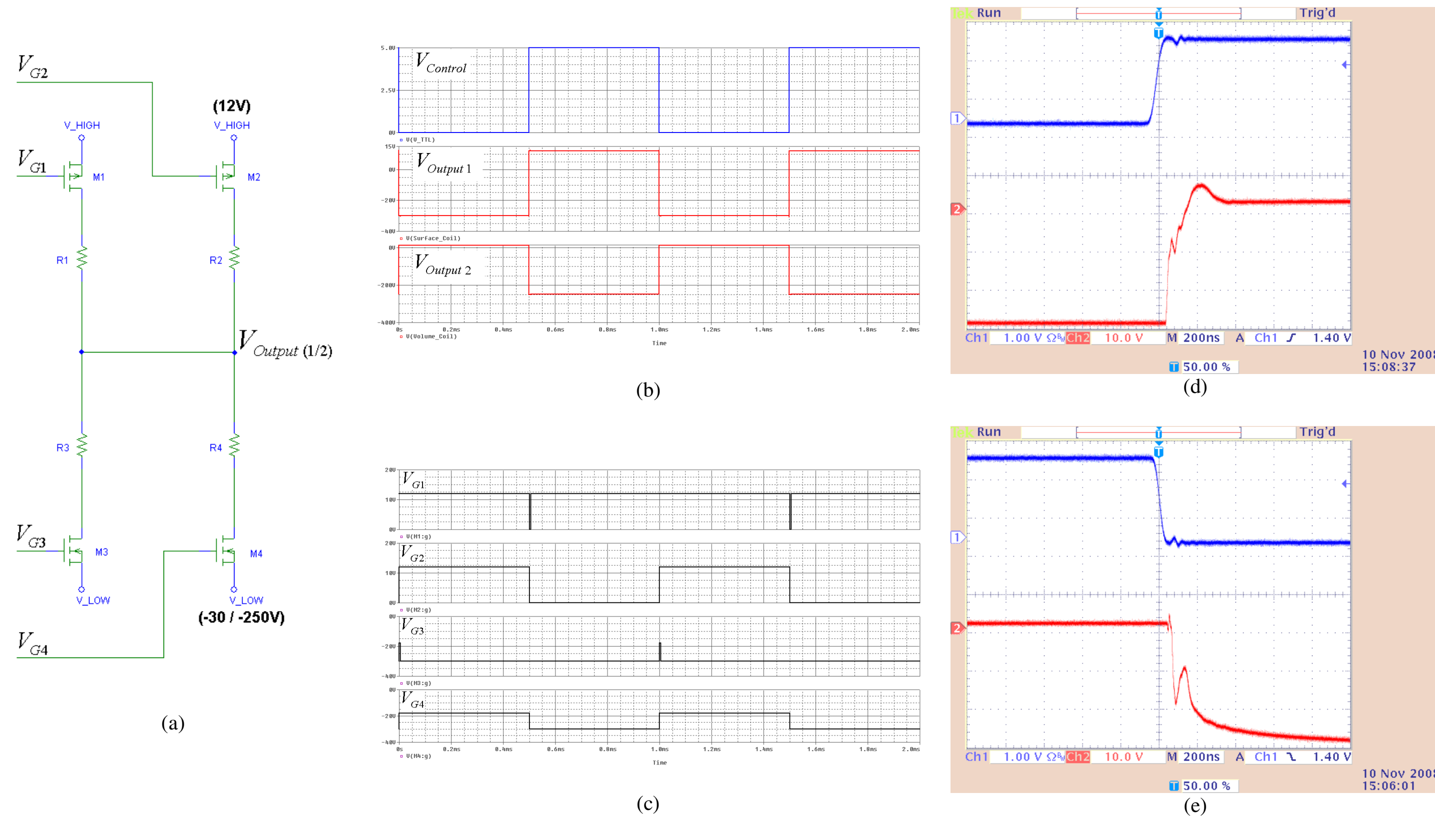


**Figure 1: (a) Reconfigurable MOSFET drive circuit; (b) Switching waveforms: TTL Control Signal from the MR console, Coil Output 1 Voltage (for Surface Coil), Coil Output 2 Voltage (for Volume Coil); (c) MOSFET gate control signals; (d) Measured low-to-high transition time of TTL control signal and $V_{output\ 1}$; (e) Measured high-to- low transition time of TTL control signal and $V_{output\ 1}$.**

## CONCLUSION

A reconfigurable circuit capable of providing either a -30V or -250V reverse bias voltage for PIN diode controlled coil systems was designed, constructed, and tested. The switching time between tune and detune states is typically within 1μs, although faster transition times can be achieved by fine-tuning of the MOSFET gate driver circuitry.

## REFERENCES

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