Wireless Clock for Magnetic Tracking Synchronization

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Introduction

- The motivation of this project is to provide a wireless clock suitable for implementation in the sensor nodes of an EMT system.
- The purpose of this design is to offer greater mobility to the sensor nodes, without compromising clock synchronization function.

Electromagnetic Tracking (EMT)

- Real time tracking of the position and orientation of the sensor, within the patient.
- Used in orthopaedics and neurosurgery.
- EMT inductive magnetic sensors operate by Faraday's law, $V = -\frac{\partial \Phi}{\partial t}$
- $\Phi = B \cdot n\, A_c$.

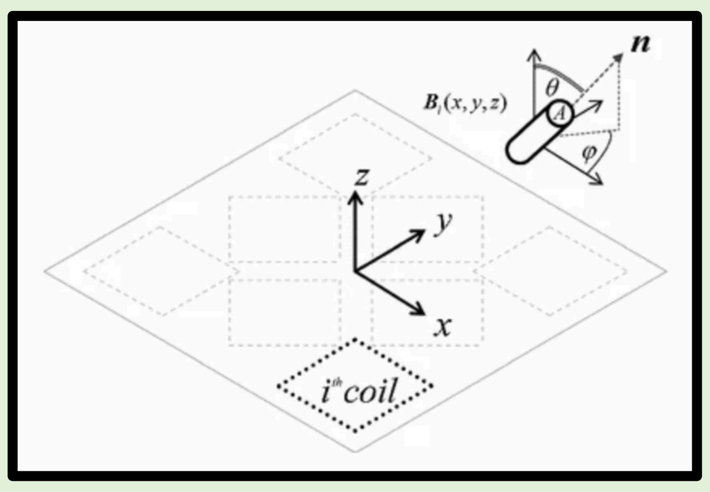

Figure 1: EMT operation [2, H. A. Jaeger].

Alternative Clock Solutions

Wired Clock

- Lack of mobility of sensor nodes.

GPS Clock

- Exorbitant fixed cost.
- Large power demand.
- Not suitable for use in sensor nodes.
- Inoperable in indoor settings.

Relevant Theory

- Let $x_1(t) = Ae^{j2\pi f_1 t}$ and $x2(t) = Ae^{j2\pi f_2 t}$. [1 , K. Alemdar]
- This superposition of waves, $S_{tx}(t) = 2cos(2\pi((\frac{f_1 - f_2}{2})t)\, e^{j2\pi(\frac{f_1+f_2}{2})t}$
- One part oscillates with the average frequency $f_{avg} = f_1 + f_2$.
- The other part is a cosine wave which oscillates with the difference frequency $f = f_1 - f_2$.
- Envelope crosses the zero mark twice in every period.
- $f_{env} = |f_1 - f_2|$.

Project Block Diagram

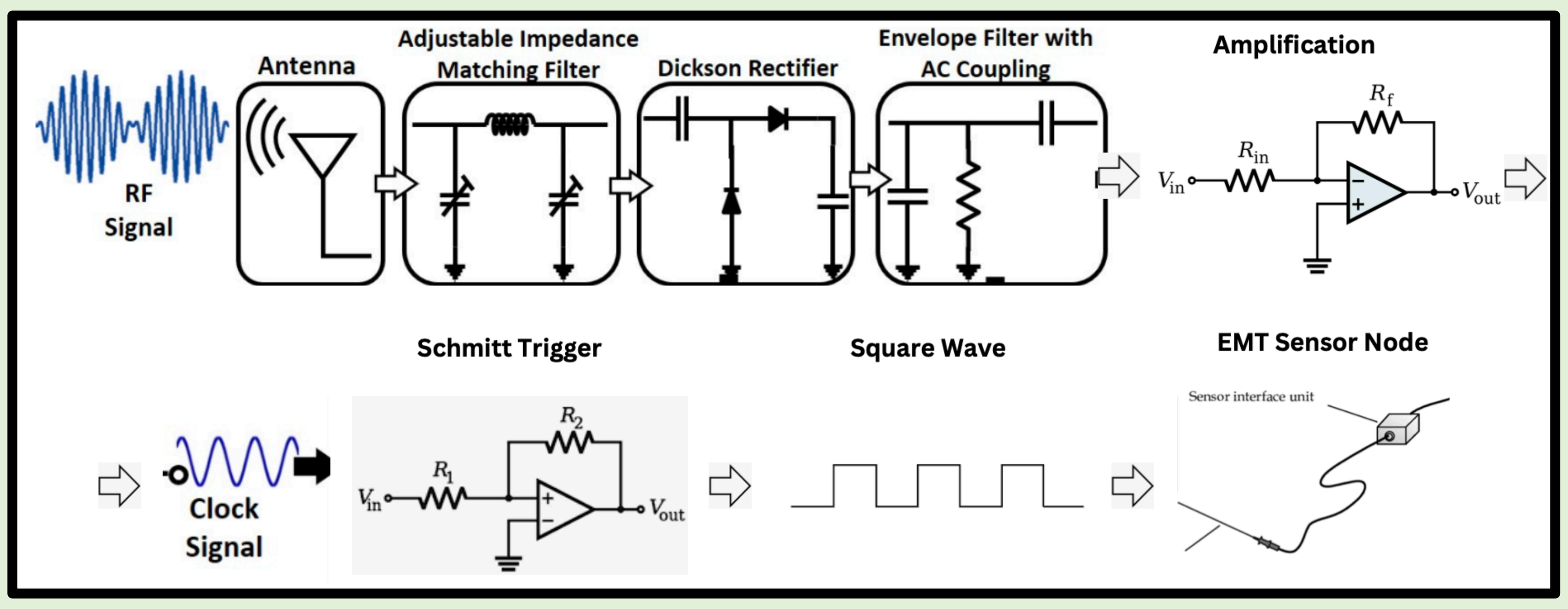

Figure 2: Project block diagram[1].

Simulink

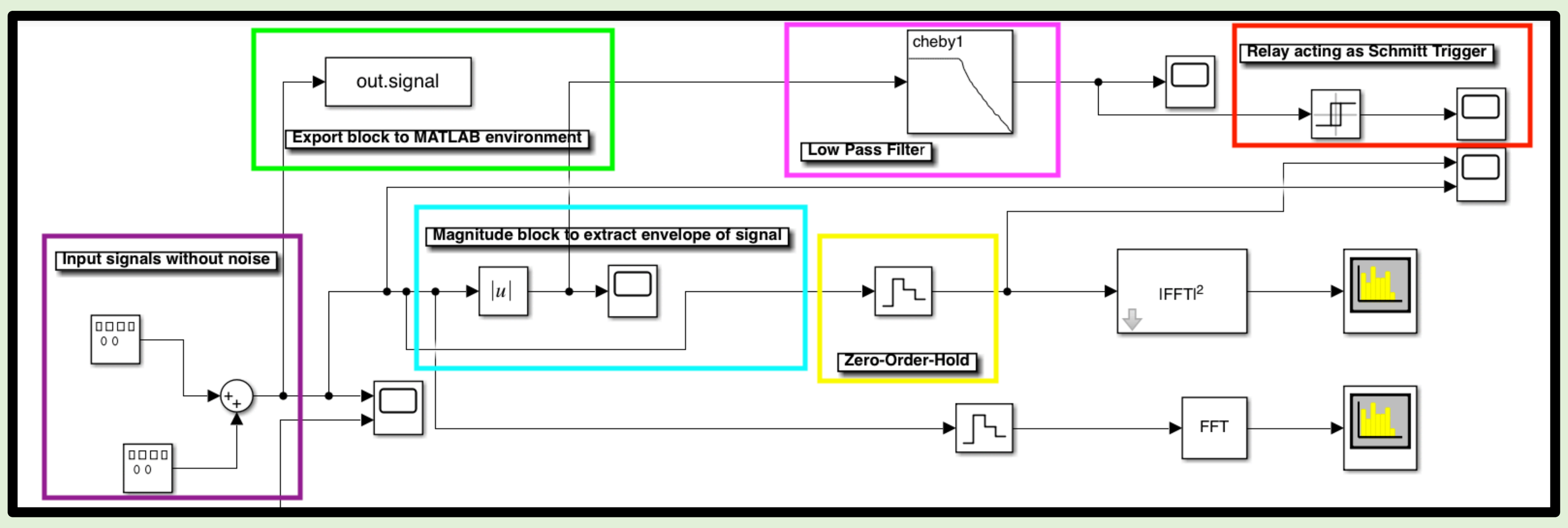

Figure 3: Simulink Schematic.

Simulink Results

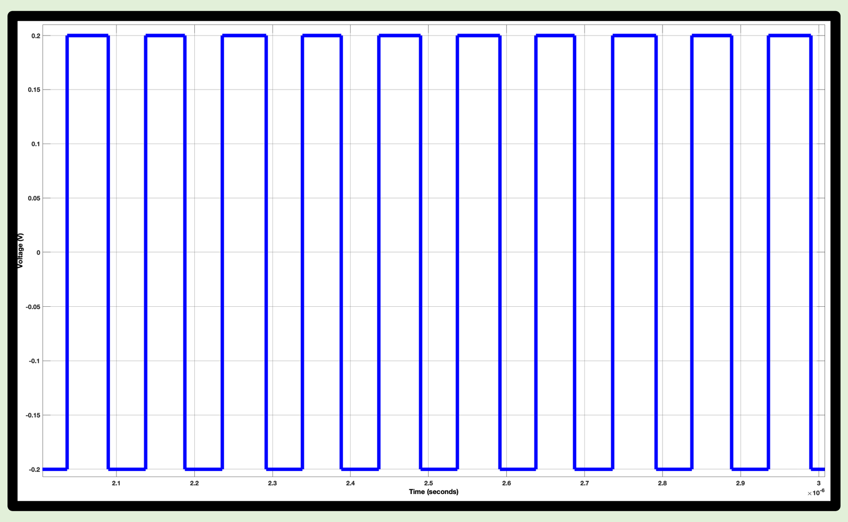

Figure 4: 50% duty cycle clock output.

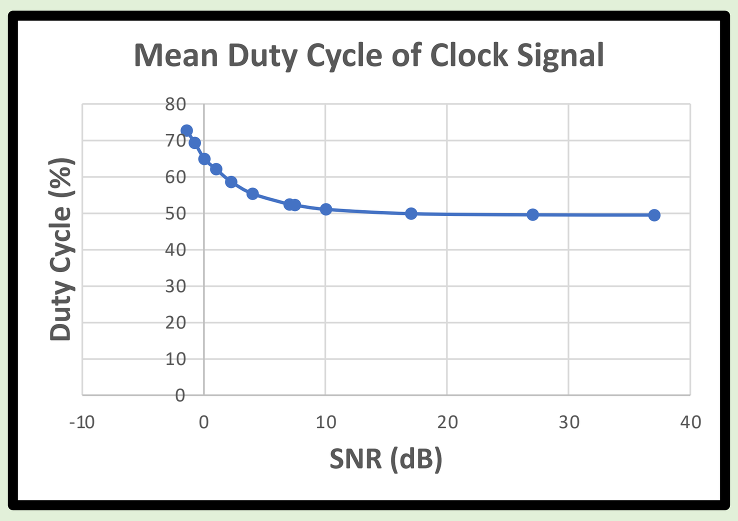

Figure 5: Mean duty cycle of output against SNR.

LTspice

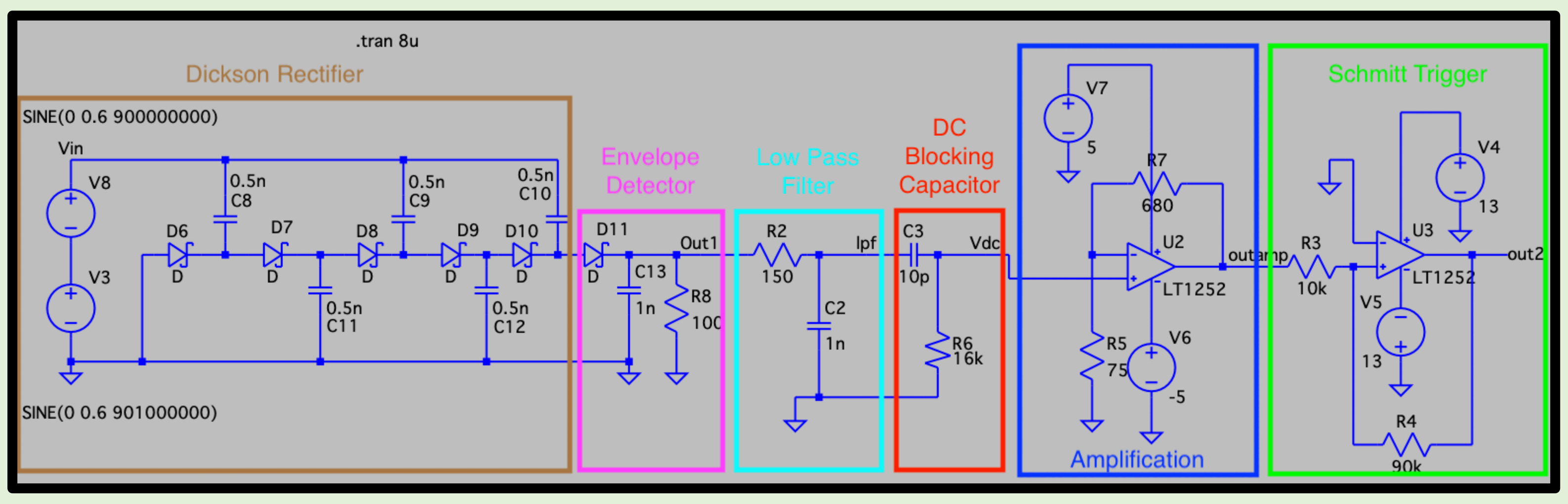

Figure 6: LTspice Schematic.

LTspice Results

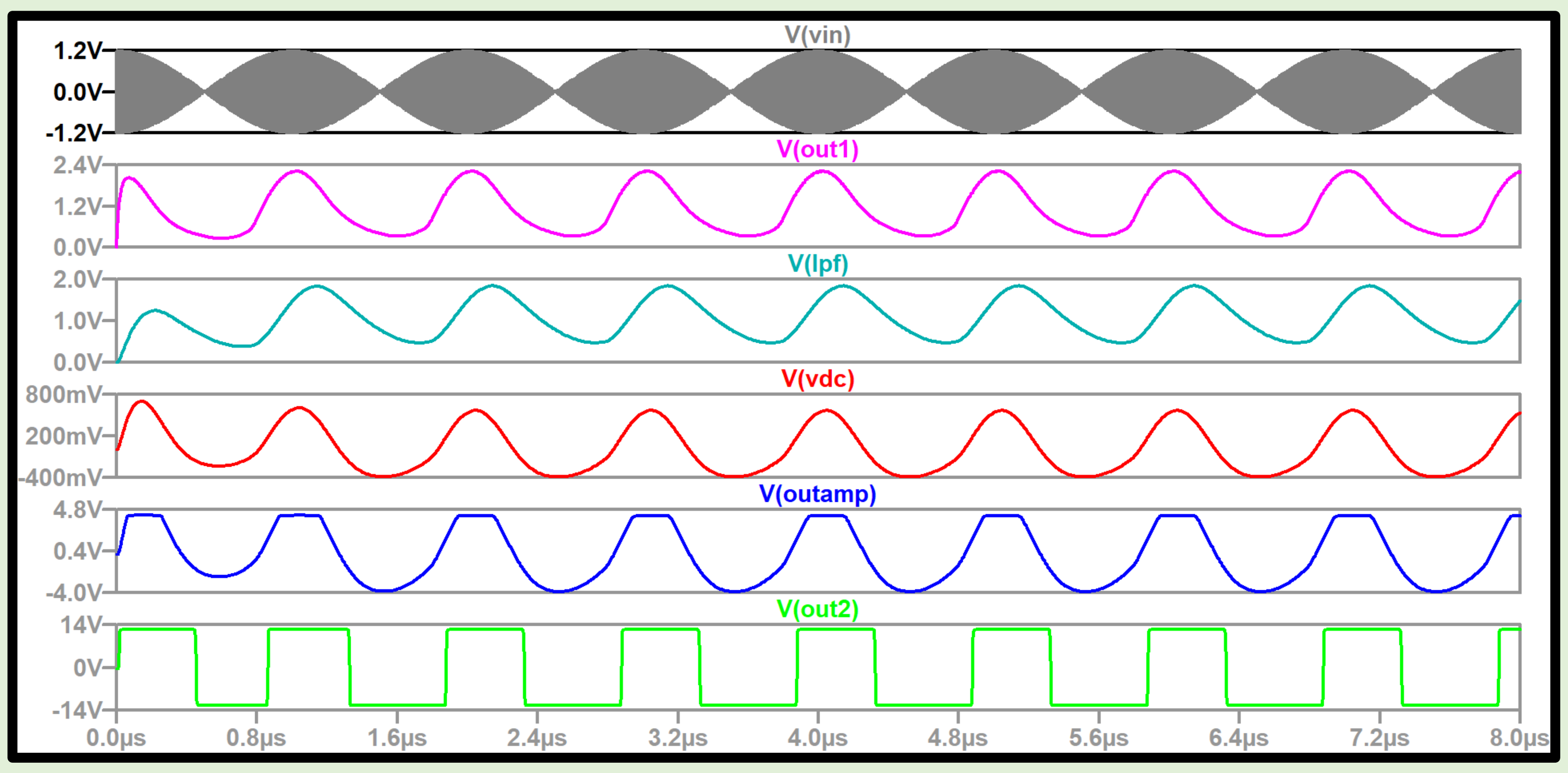

Figure 7: LTspice simulation results.

Altium

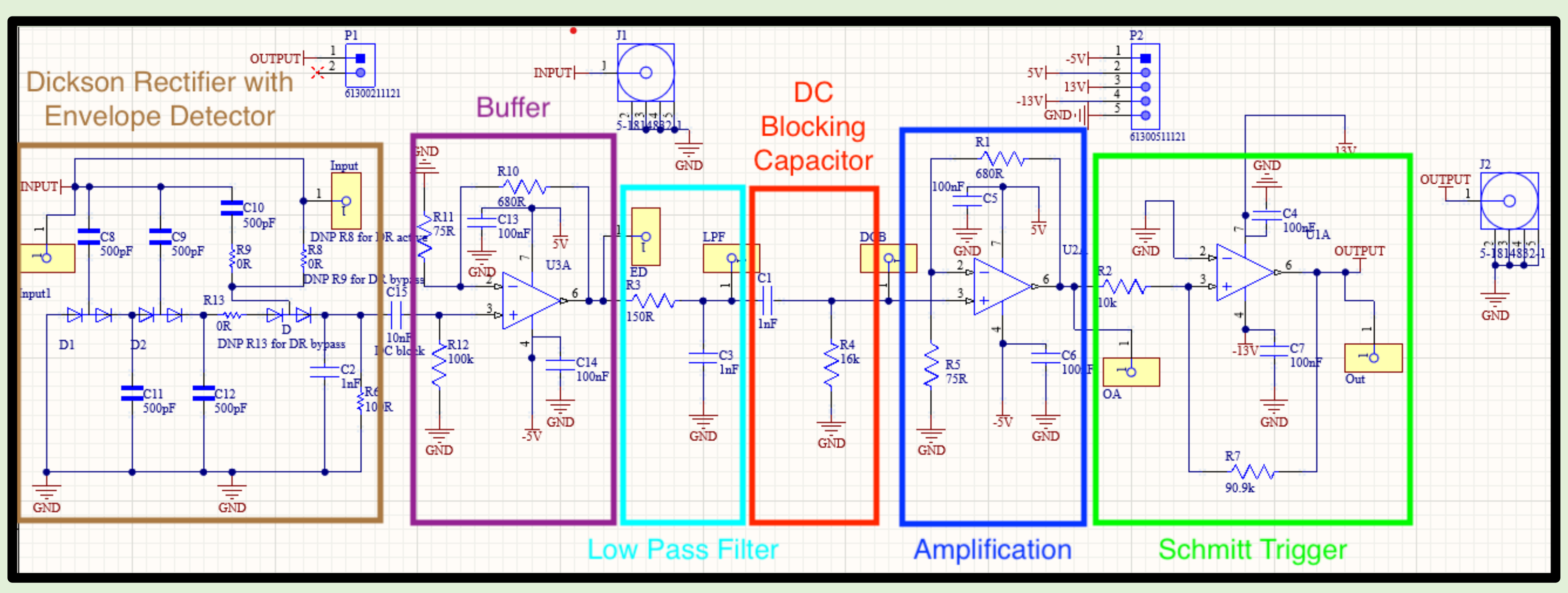

Figure 8: Altium Schematic.

PCB Design

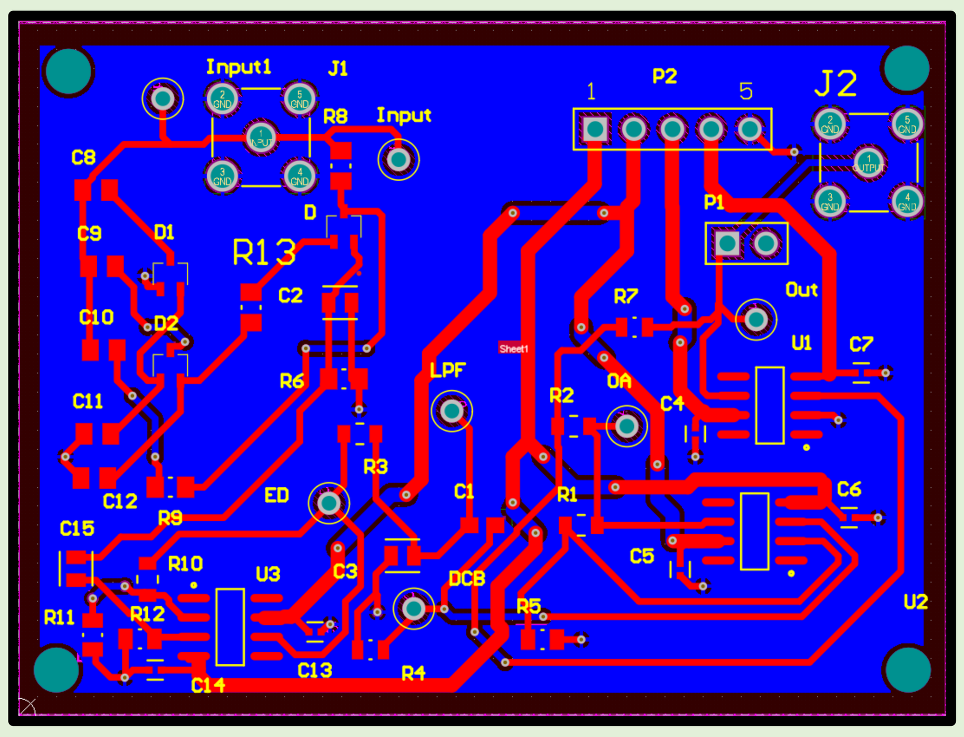

Figure 9: Altium 2D Layout.

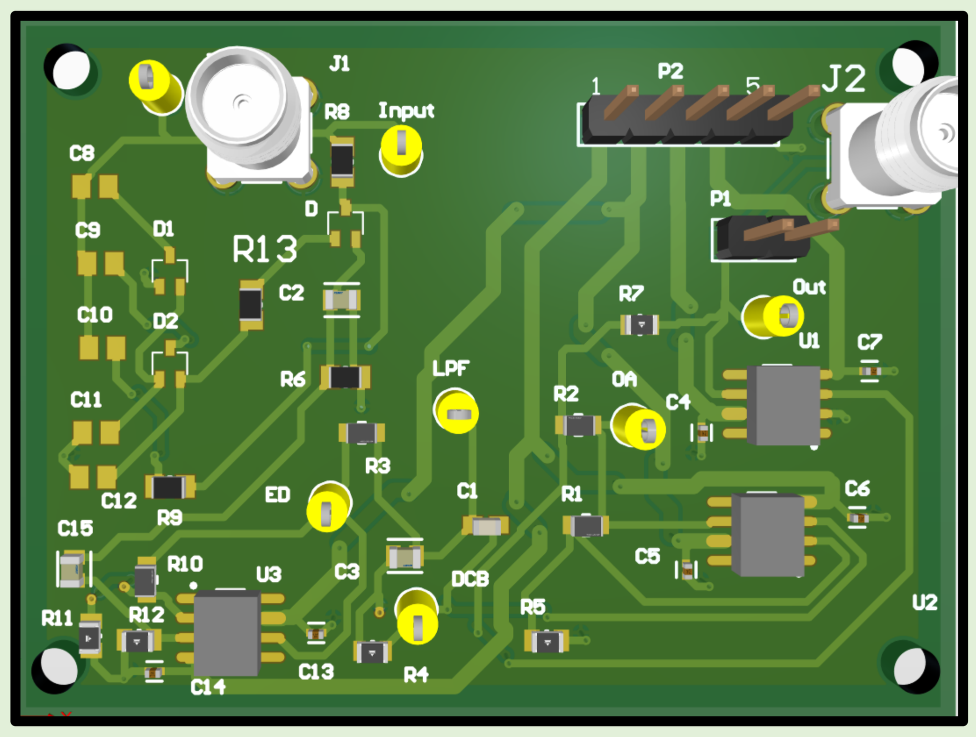

Figure 10: Altium 3D Model.

Results

- A successful implementation of the design and its performance metrics have been achieved, in both the Simulink and LTspice environment.
- Sufficient clock performance is defined as the clock signal maintaining a 50% duty cycle, as seen in Figure 4.
- System operates effectively for SNR values of SNR>=7.0332dB., as demonstrated in Figure 5.

References

- [1] K. Alemdar, D. Varshney, S. Mohanti, U. Muncuk, and K. Chowdhury, "RFClock: timing, phase and frequency synchronization for distributed wireless networks," in *Proceedings of the 27th Annual International Conference on Mobile Computing and Networking*, New Orleans Louisiana, Sep. 2021, pp. 15–27. doi: 10.1145/3447993.3448623.
- [2] H. A. Jaeger *et al.*, "Anser EMT: the first open-source electromagnetic tracking platform for image-guided interventions," *Int J CARS*, vol. 12, no. 6, pp. 1059–1067, Jun. 2017, doi: 10.1007/s11548-017-1568-7.