Virtual Research Presentation Conference

All-Digital Ground Penetrating Radar

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Program: Topic

RP-137

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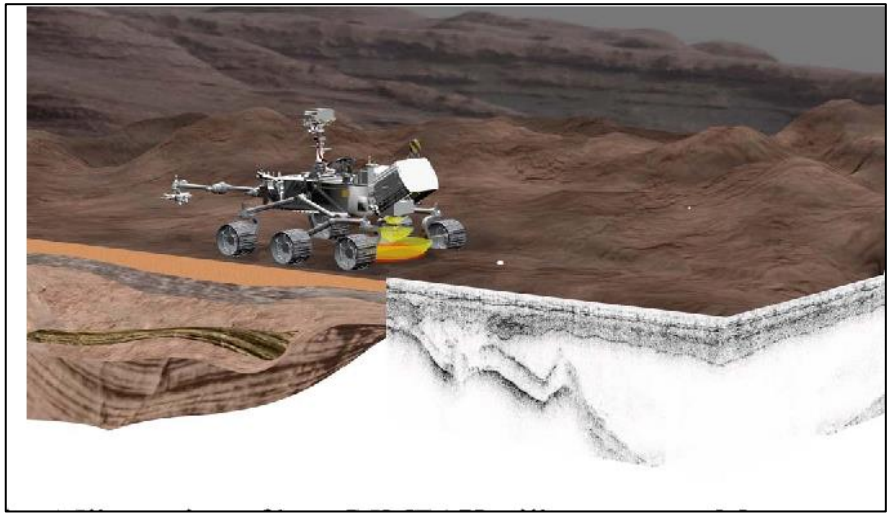
Tutorial Introduction

GPR is a powerful tool for sub-surface exploration:

- Explore sub-surface features of planetary bodies including ice deposits on Mars and the icy shell of outer planet moons like Europa.
- Also useful for lunar prospecting to find resources in support of human exploration missions.
- Emerging need for a compact and versatile GPR instrument for these applications.

RimFax Radar on M2020

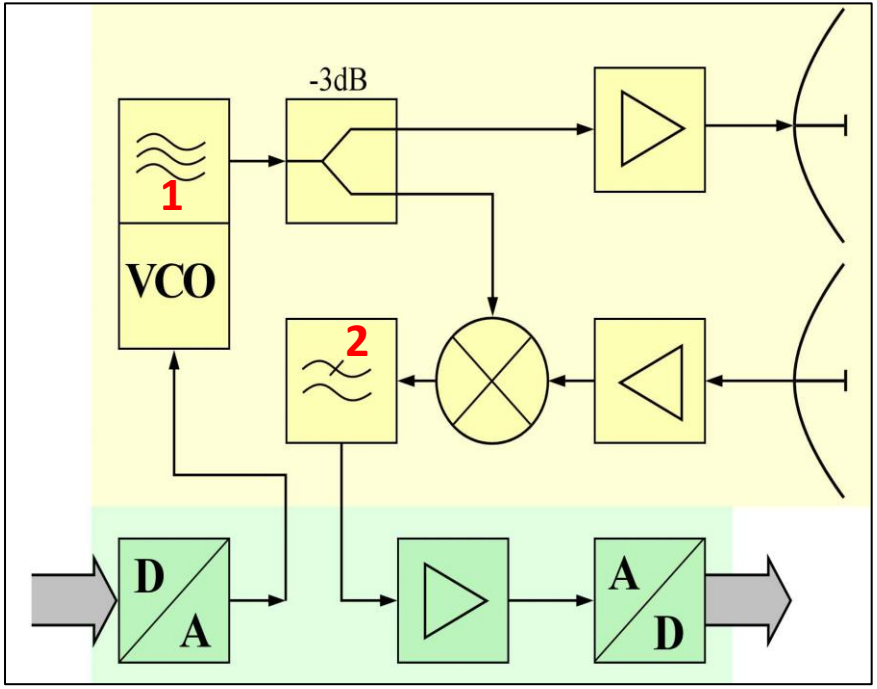


Problem Description

GPR Typically based on microwave circuits

- Frequencies and bandwidths are fixed-tuned and must be committed to prior to launch.
- Makes the resolution, bandwidth and penetration of the radar unable to adapt to any unexpected subsurface conditions.
- Filters re related to both up/down conversation stages, and anti-aliasing filters on the data-converters.

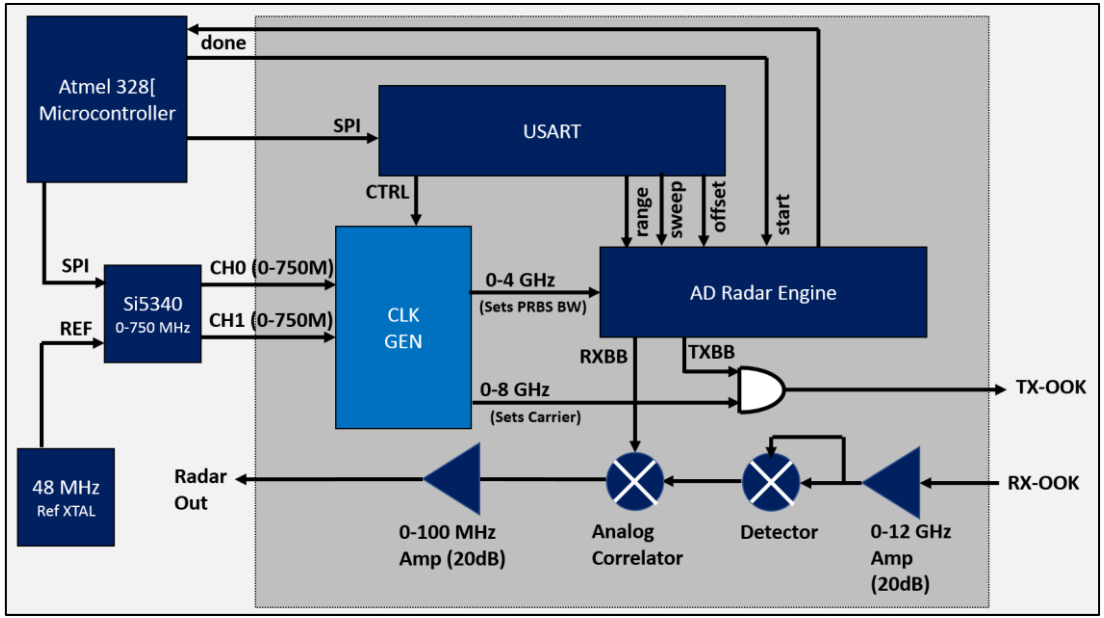
Typical Radar Block Diagram



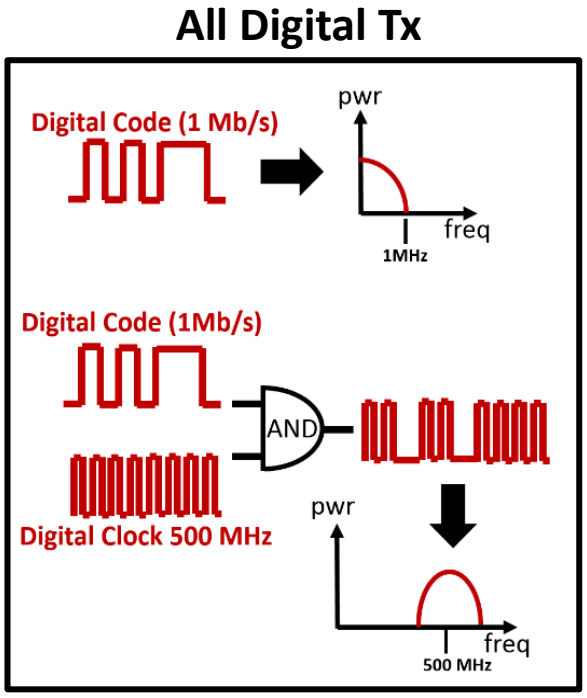
Methodology – Block Diagram

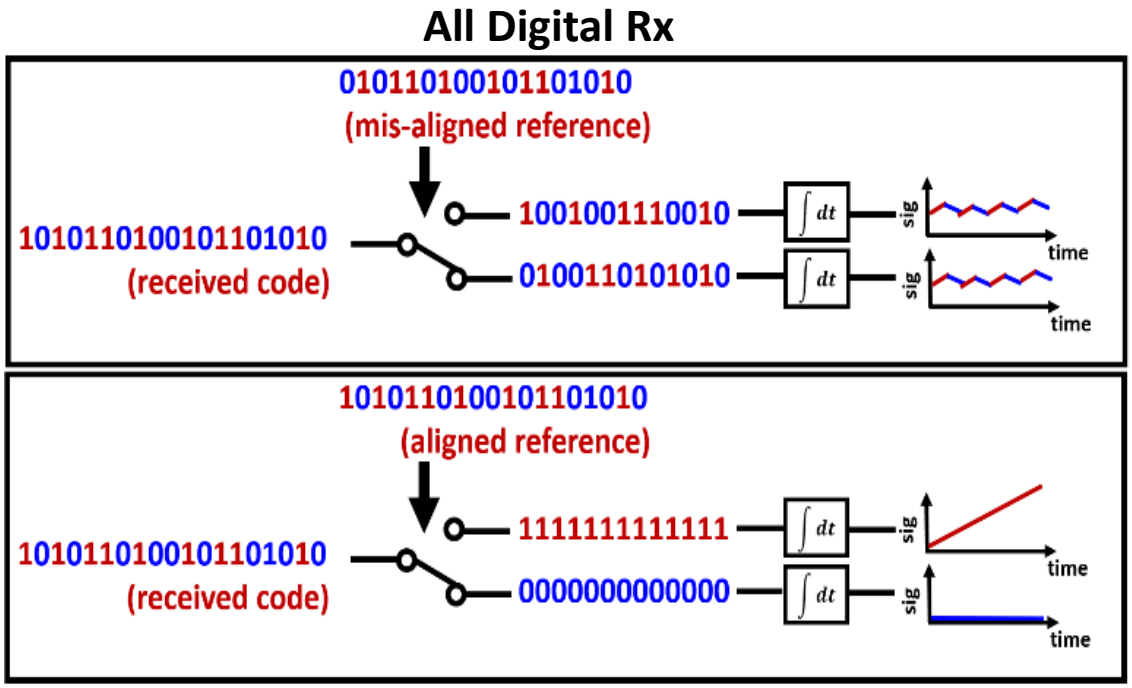
Reimagine Radar From Scratch

- An all-digital implementation of a radar system which works on digital codes instead of pulses or chirps.
- No A/D or D/A converter, no LO, and no up/down conversion stages, entirely digital circuitry.
- Frequency and bandwidth are 100% in-situ programmable. Covers 0-4 GHz with a single chip..



Methodology – Transmit and Receive Scheme

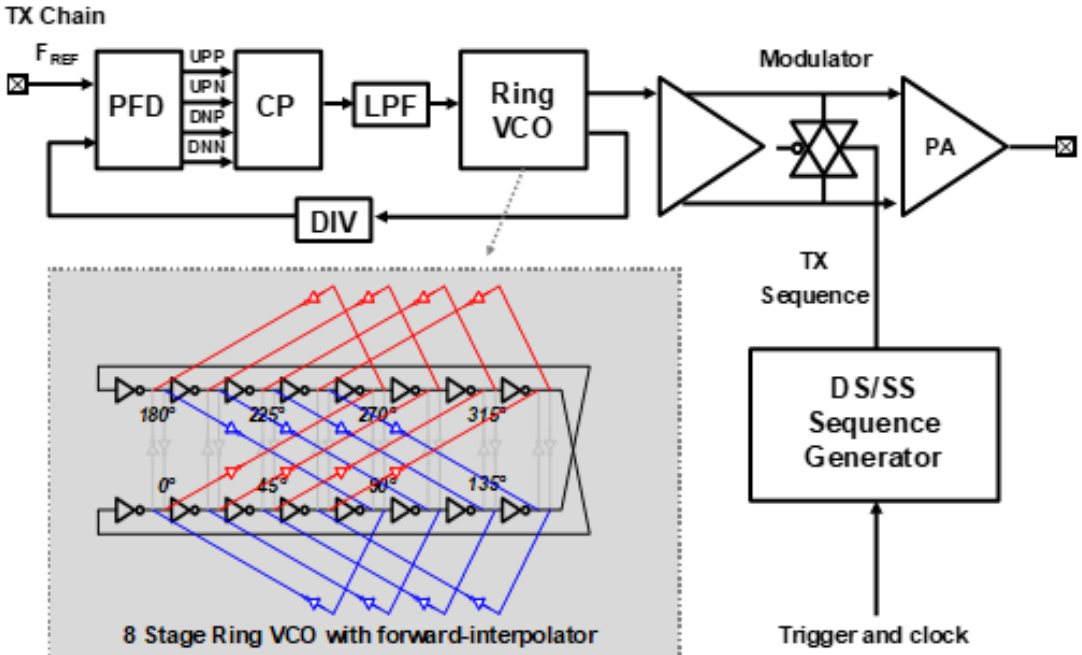




Methodology – Transmit Circuitry

Key Circuit Features

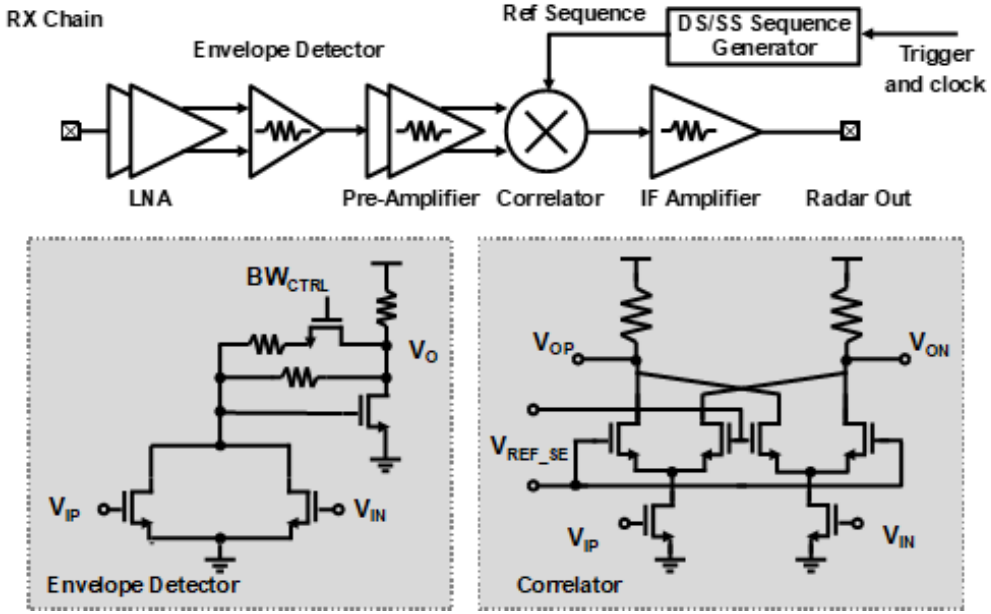
- Clocking PLL based on a ring VCO with feed-forward stage interpolation to keep phase noise down.
- Direct ASK modulator from the digital sequence generator into the amplifier stage.
- The amp is broadband and resistively loaded (not LC like an RFIC) to allow broad bandwidth.



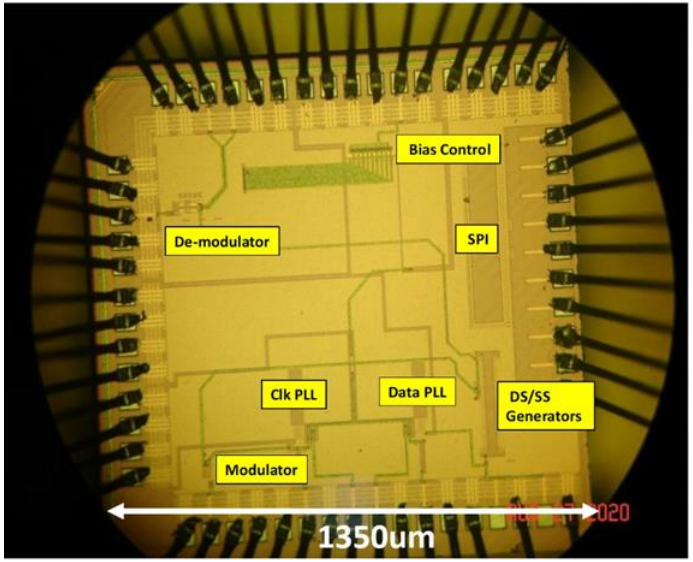
Methodology – Transmit Circuitry

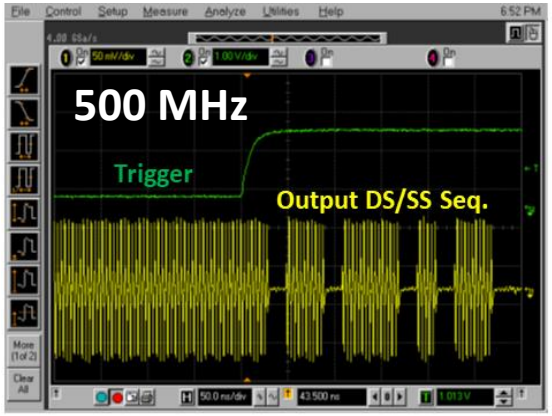
Key Circuit Features

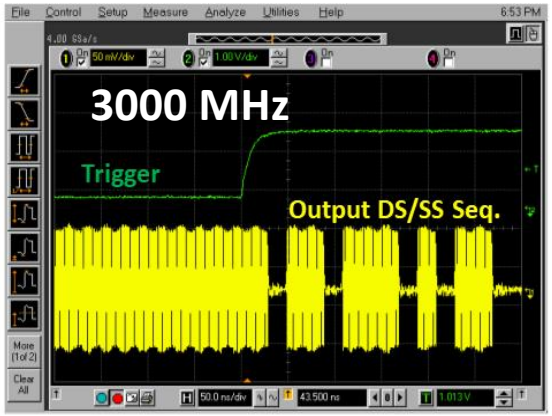
- The front-end amps are again broadband and resistively loaded to allow broad bandwidth.
- Push-push envelope detector to demodulate the OOK DS/SS code
- Resistive 4 quadrant multiplier to perform code correlation. DS/SS generator is a duplicate unit of the one in the TX (So the code sequence is the same).

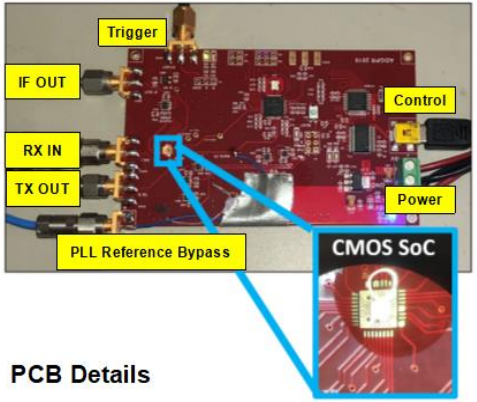


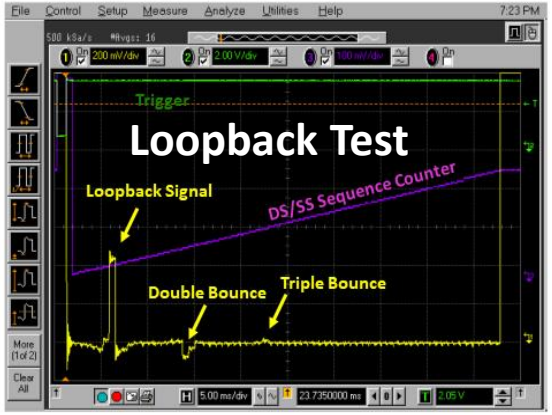
Results





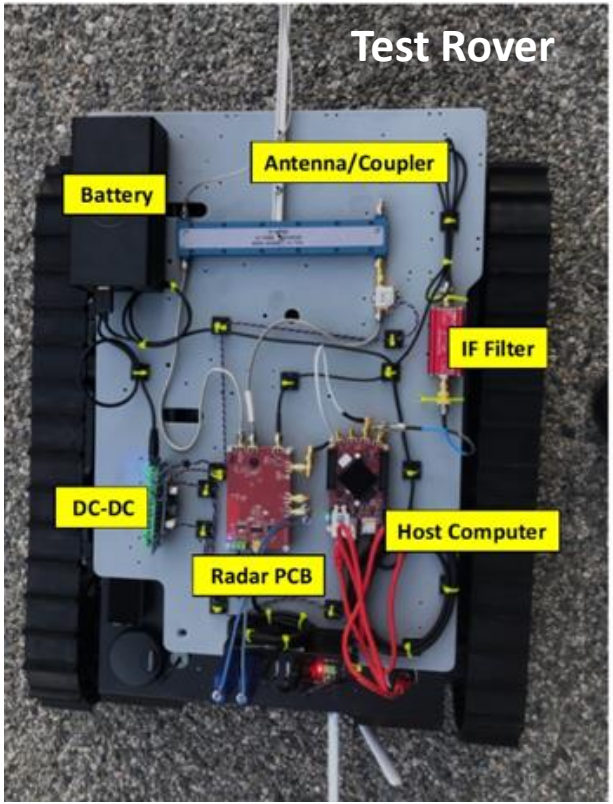


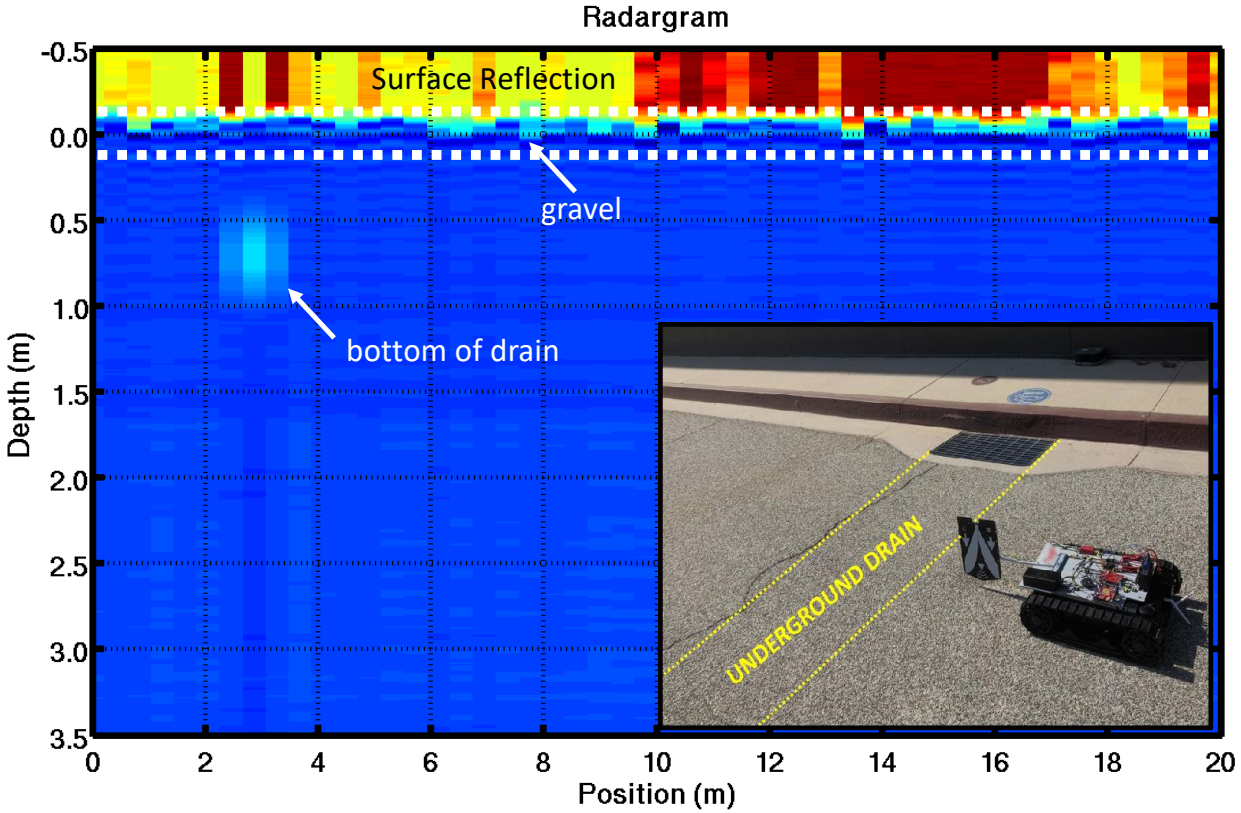




- Lab testing of the chip done completed just before the covid shutdown (Mar 15). This is with a cable test.

Results





- Roadway behind bldg. 300. Tested in Sept 2020.

Publications and References

Very Recent Submissions (delays in testing data)

1. Rulin Huang et.al “A 0.1-4.0 GHz and 46mW Inductor-less DS/SS Ground Penetrating Radar with Programmable Carrier Frequency and Bandwidth for Planetary Exploration in 28nm CMOS” – submitted ISSCC 2021