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RES.LL-003 | January IAP 2011 | Undergraduate

Build A Small Radar System Capable Of Sensing Range, Doppler, And Synthetic Aperture Radar Imaging

https://ocw.mit.edu/courses/res-ll-003-build-a-small-radar-system-capable-of-sensing-range-doppler-and-synthetic-aperture-radar-imaging-january-iap-2011/

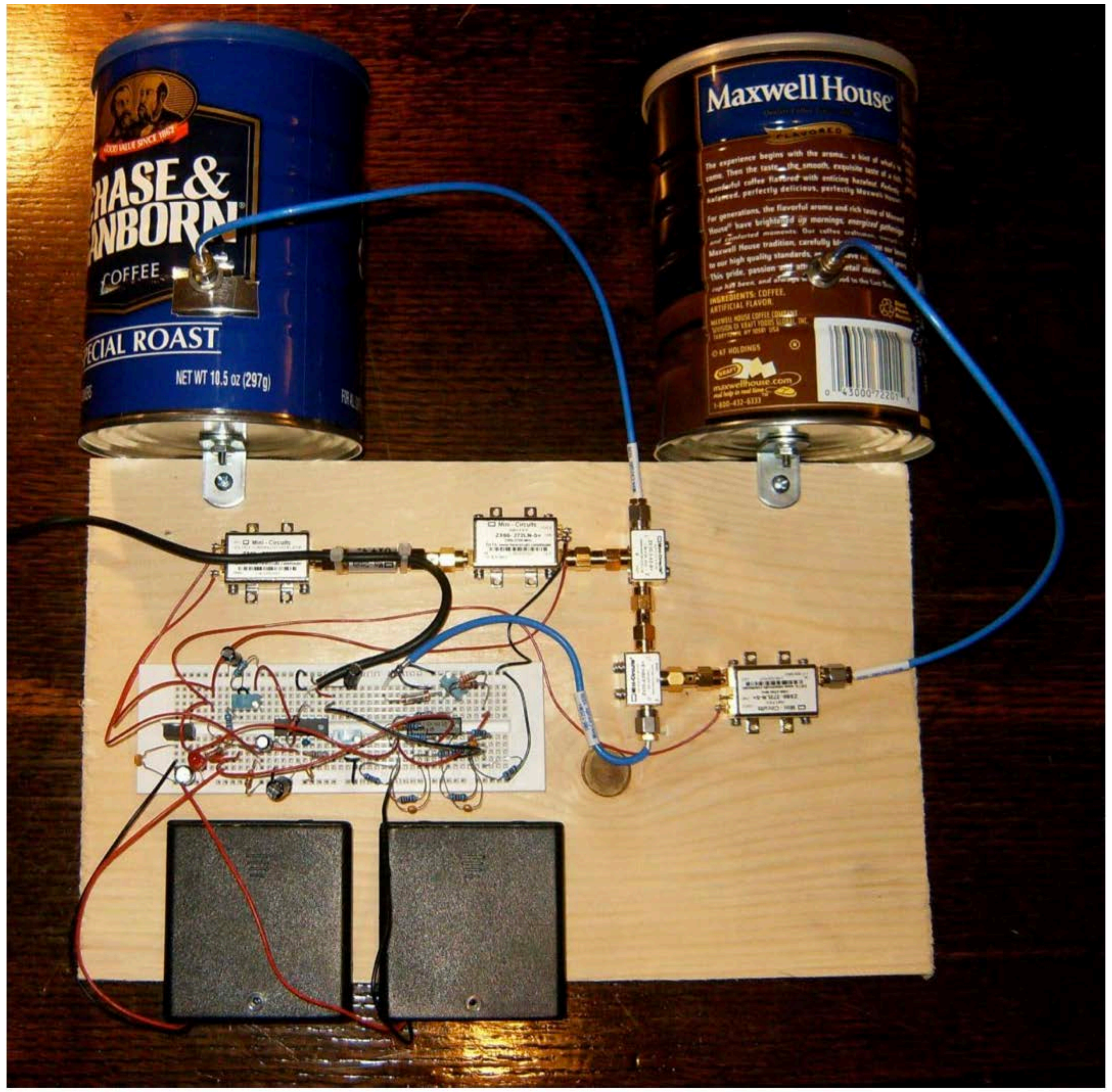
MIT IAP 2011 Laptop Based Radar: Block Diagram, Schematics, Bill of Material, and Fabrication Instructions*

Presented at the 2011 MIT Independent Activities Period (IAP)

Gregory L. Charvat, PhD
MIT Lincoln Laboratory

10-28 January 2011

*This work is sponsored by the Department of the Air Force under Air Force Contract #FA8721-05-C-0002. Opinions, interpretations, conclusions and recommendations are those of the authors and are not necessarily endorsed by the United States Government.



PRODUCTS APPLICATIONS DESIGN CENTER SUPPORT COMPANY STORE

Search

TEF810x Fully-Integrated 77 GHz Radar Transceiver

TEF810X ACTIVE Receive alerts

Overview Product Details Documentation Design Resources Training Support BUY/PARAMETRICS PACKAGE/QUALITY

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The TEF810X is a fully integrated single-chip RFCMOS 77 GHz automotive FMCW radar transceiver. This device is intended for usage in short-, medium- and long-range radar applications covering the full automotive radar frequency band from 76 GHz to 81 GHz. TEF810X radar transceiver is a low power radar transceiver which integrates 3 transmitters, 4 receivers, Analog-to-digital converters and low phase noise Voltage Controlled Oscillator (VCO).

This automotive radar device enables several key driver assistance and safety applications as listed below:

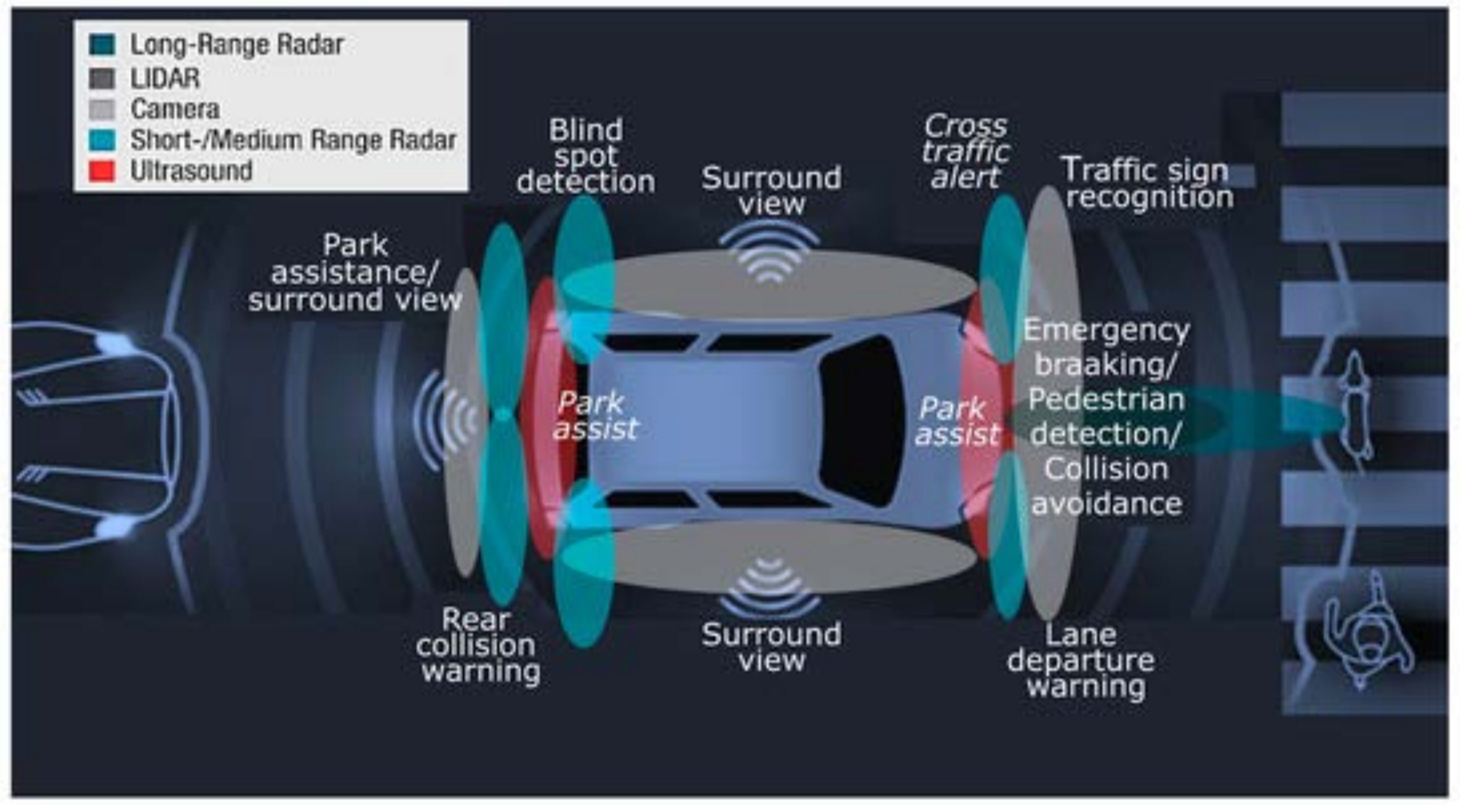
- Autonomous Emergency Braking (AEB)
- Adaptive Cruise Control (ACC)
- Blind-spot Detection/monitoring (BSD/BSM)
- Rear Cross Traffic Alert (RCTA)
- Front Cross Traffic Alert (FCTA)
- Rear Collision Avoidance (RCA)
- Parking Assist (PA)
- Rear Occupant Detection/Alert (ROD/ROA)
- Cocoon Radar
- Imaging Radar

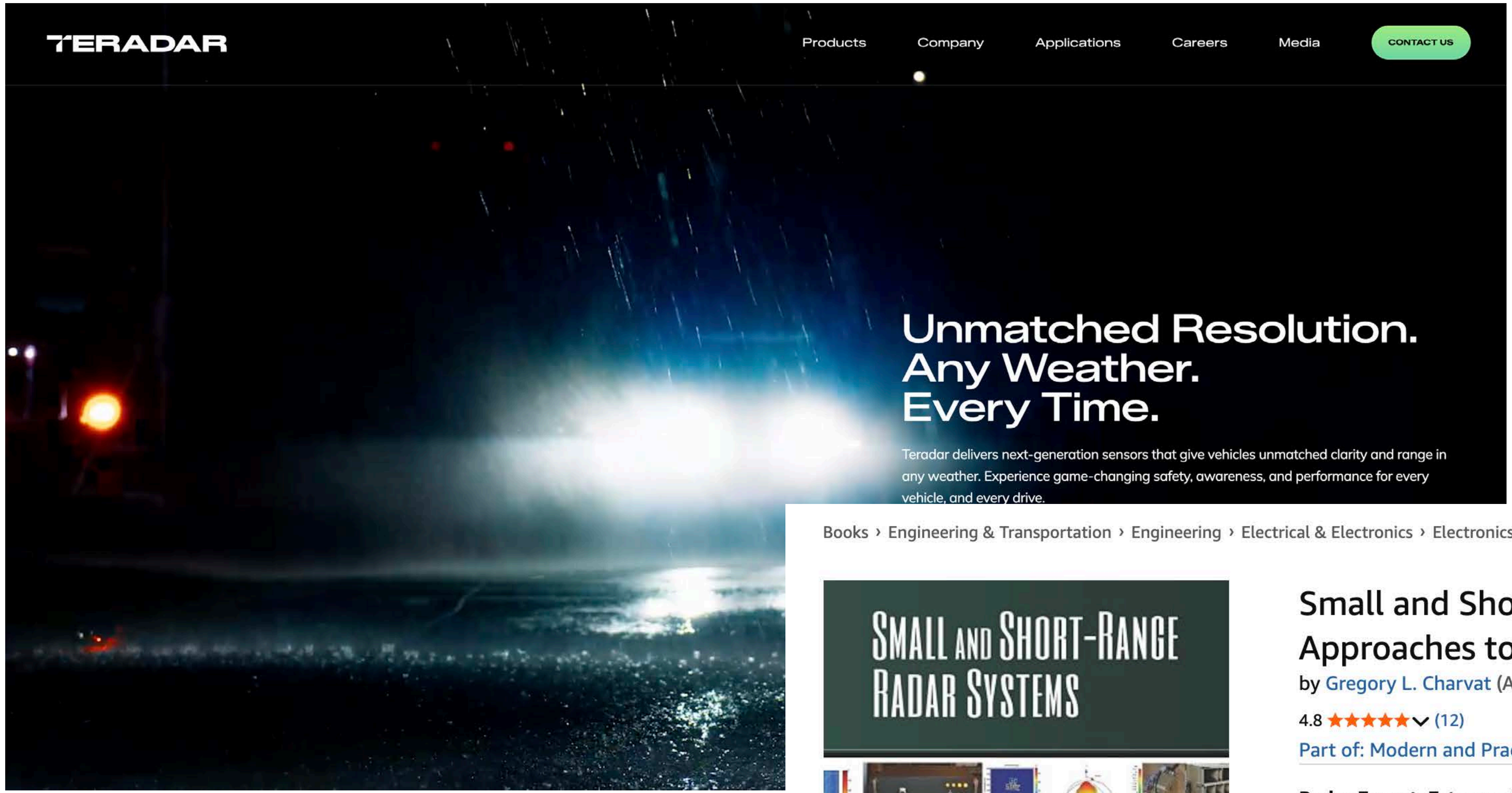
Less

DATA SHEET 3D

PDF to Key

Near-mm wave radars are now ubiquitous..

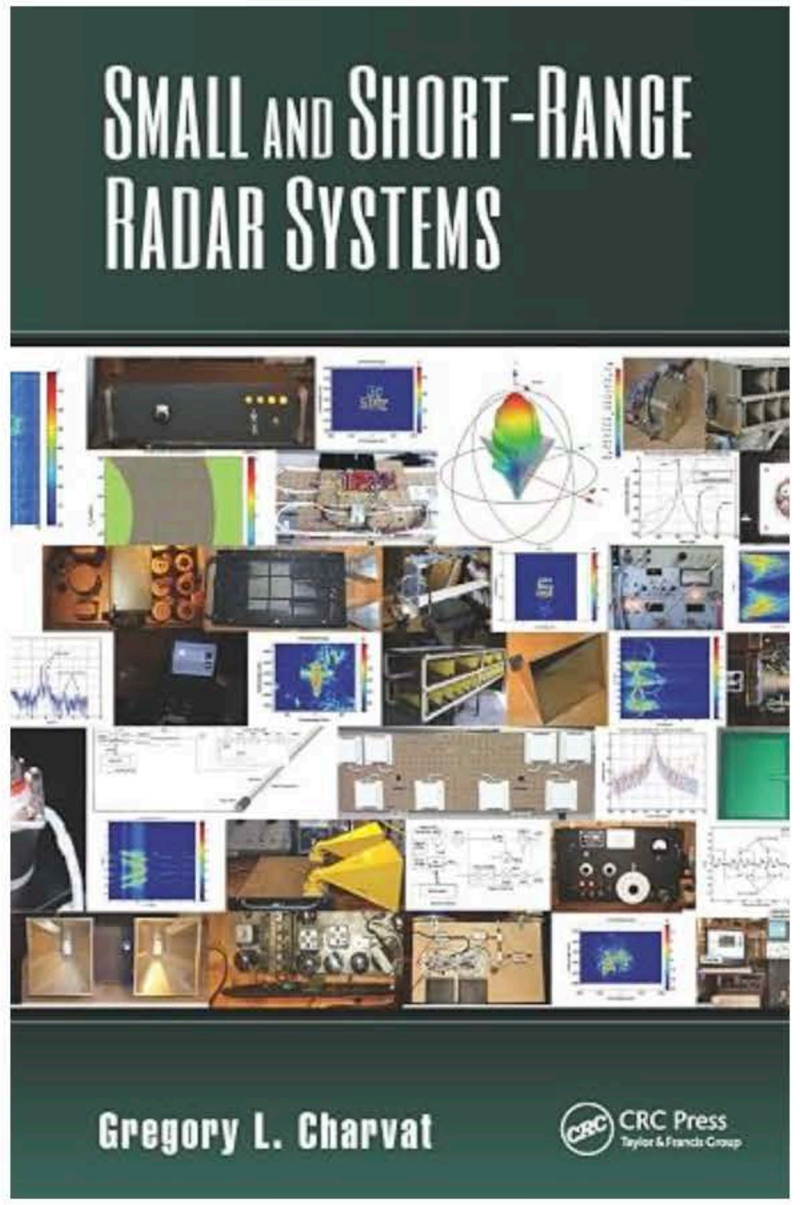




Greg Charvat
former MIT Lincoln
CTO, Teradar

300 GHz - 3 THz
automotive radar

Books › Engineering & Transportation › Engineering › Electrical & Electronics › Electronics › Sensors



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Small and Short-Range Radar Systems (Modern and Practical Approaches to Electrical Engineering)

by Gregory L. Charvat (Author) | Format: Hardcover

4.8 ★★★★★ (12)

Part of: Modern and Practical Approaches to Electrical Engineering (3 books)

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Radar Expert, Esteemed Author Gregory L. Charvat on CNN and CBS

Author Gregory L. Charvat appeared on CNN on March 17, 2014 to discuss whether Malaysia Airlines Flight 370 might have literally flown below the radar. He appeared again on CNN on March 20, 2014 to explain the basics of radar, and he explored the hope and limitations of the technology involved in the search for Flight 370 on CBS on March 22, 2014.

Get His Book Now

Coupling theory with reality, from derivation to implementation of actual radar systems, **Small and Short-Range Radar Systems** analyzes and then provides design procedures and working design examples of small and short-range radar systems. Discussing applications from automotive to through-wall imaging, autonomous vehicle, and beyond, the practical text supplies high-level descriptions, theoretical derrivations, back-of-envelope calculations, explanations of processing algorithms, and case studies for each type of small radar system covered, including continuous wave (CW), ultrawideband (UWB) impulse, linear frequency modulation (FM), linear rail synthetic aperture radar (SAR), and phased array. This essential

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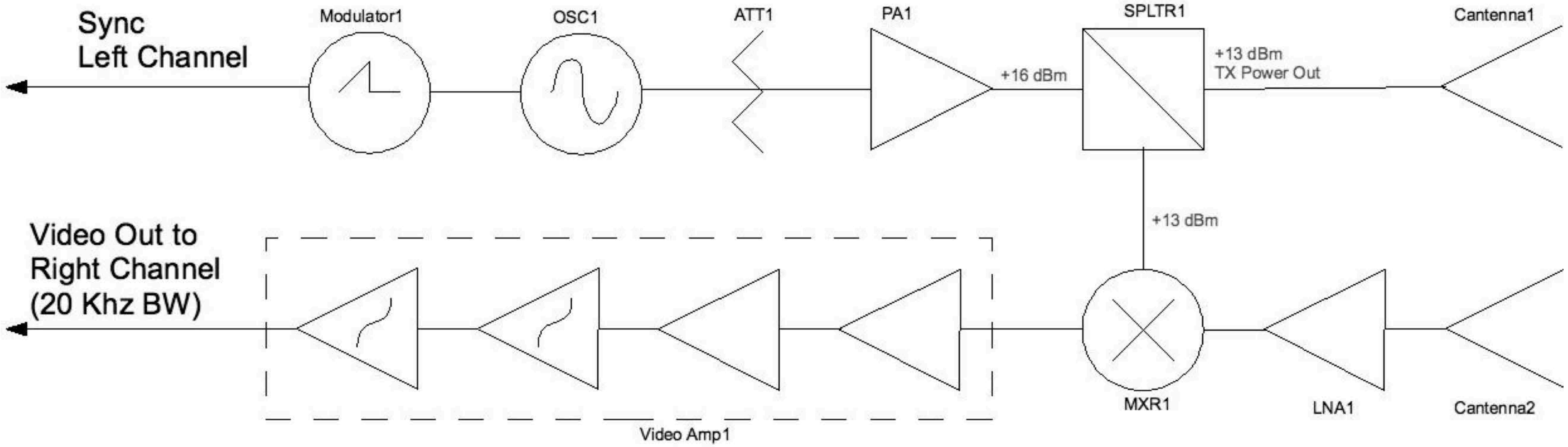
ISBN-10	ISBN-13	Edition	Publisher	Publication date
143986599X	978-1439865996	1st	CRC Press	April 4, 2014

See all details

Block Diagram



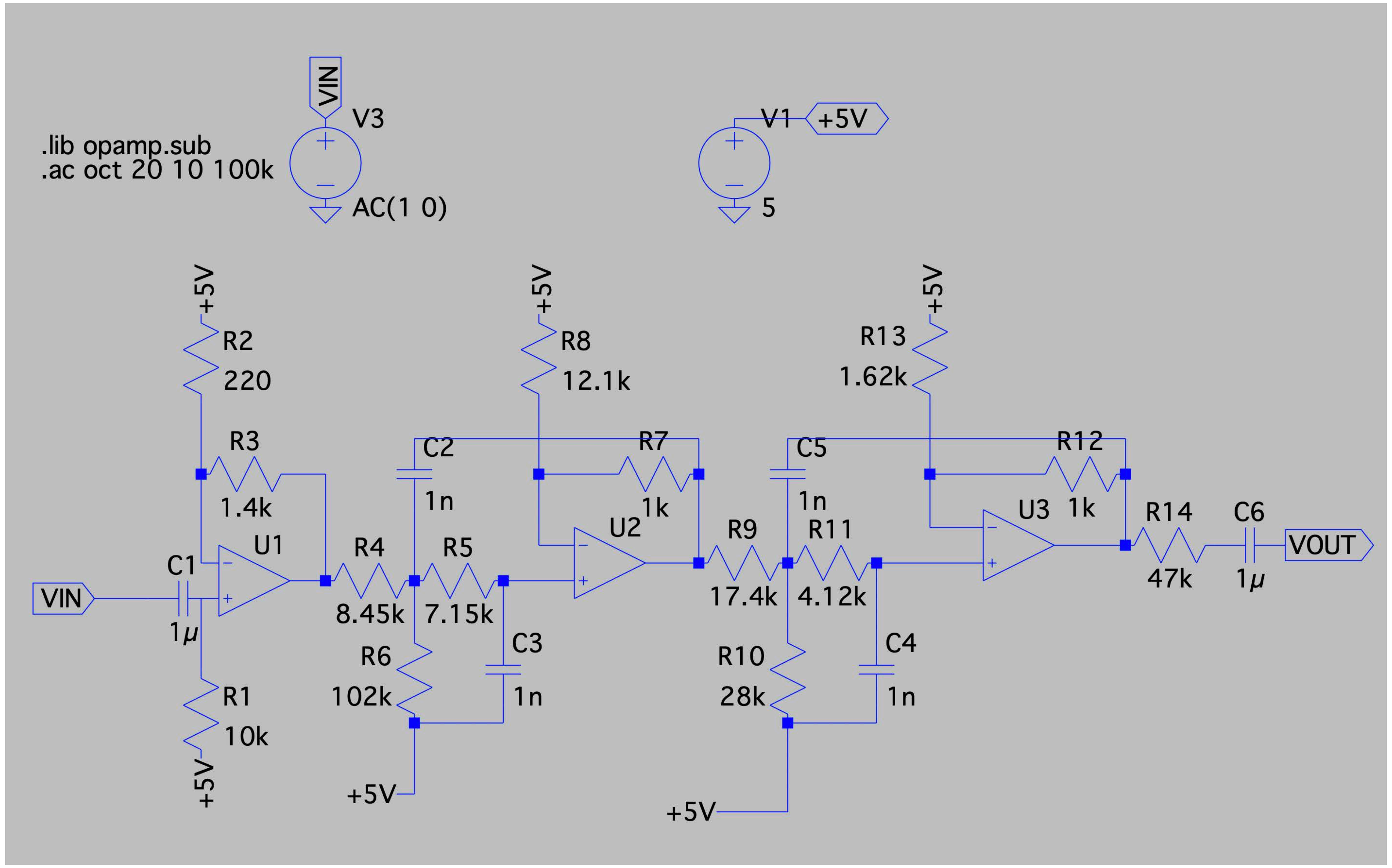
- **FMCW**
- **Operates in ISM band of 2.4 GHz**
- **approximately 10 mW TX power**
- **Max range approximately 1 km for 10 dBsm**
- **Data acquisition/signal processing in MATLAB**
  - **sound card digitizes sync pulse and de-chrip**

    Supporting FFT, 2-pulse canceller, SAR image

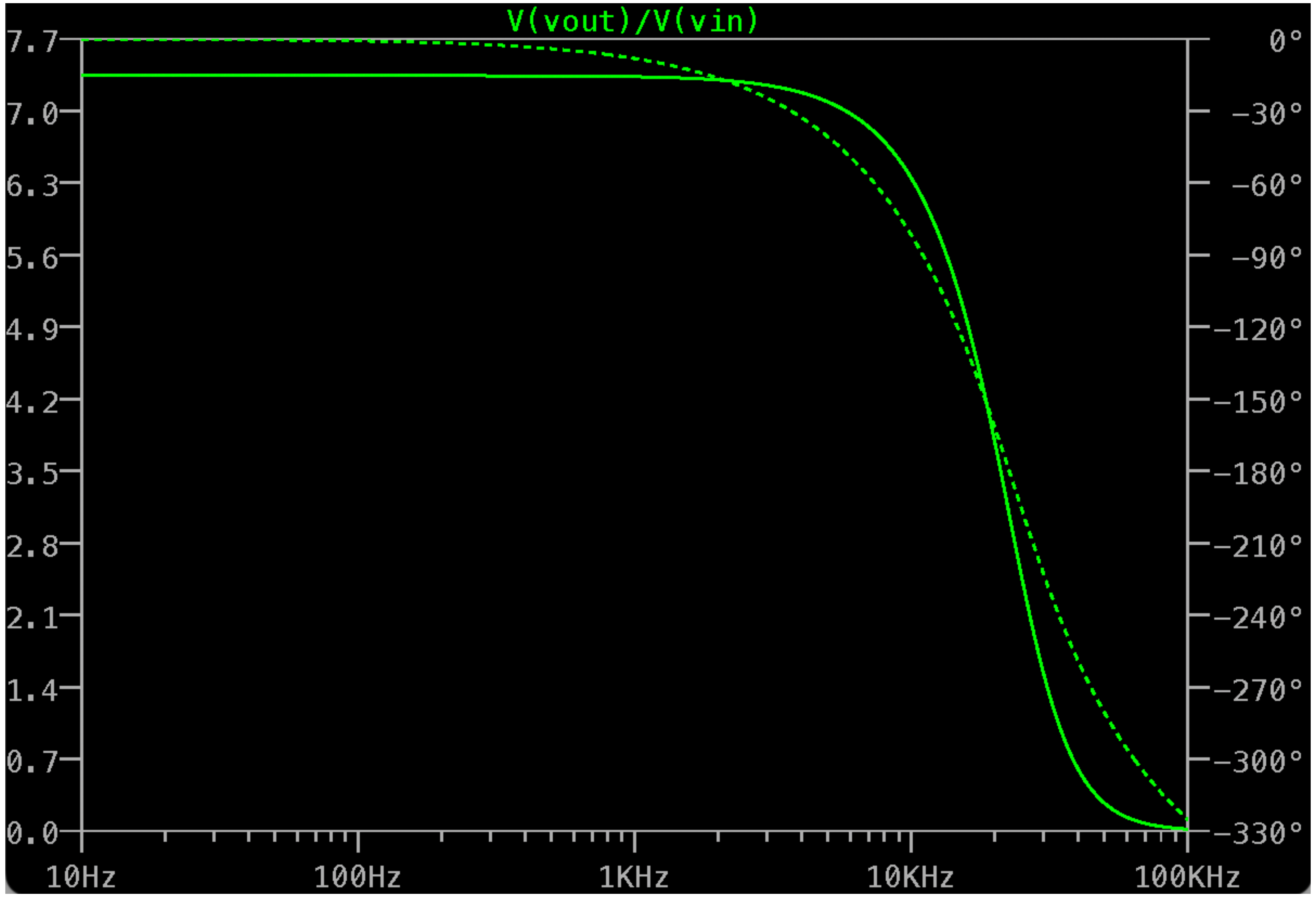
We will demonstrate:

- Doppler mode
- Ranging mode

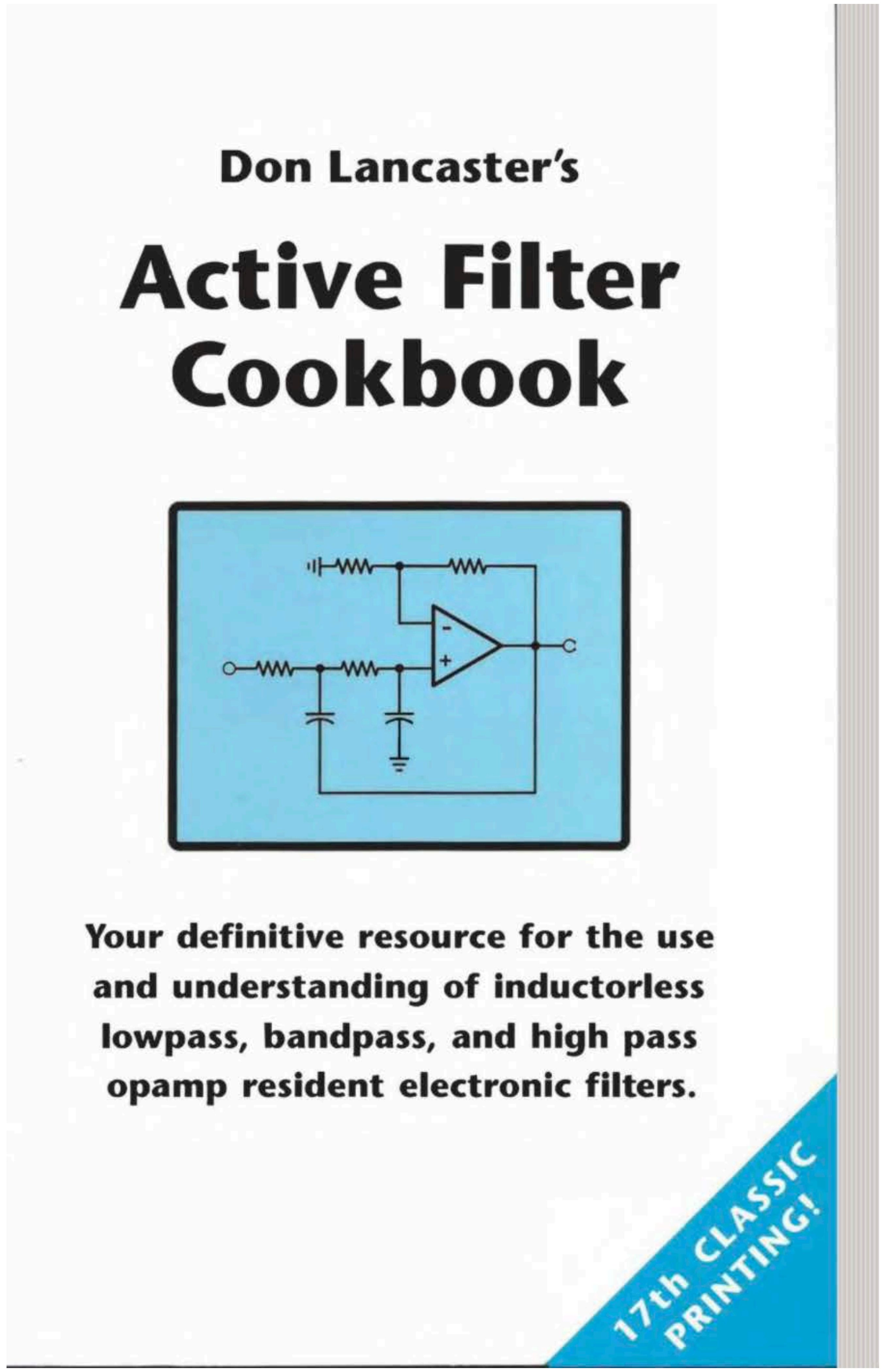
15 kHz Active 2-Stage Low Pass Filter With Gain Stage



Gain LPF stage1 LPF stage2

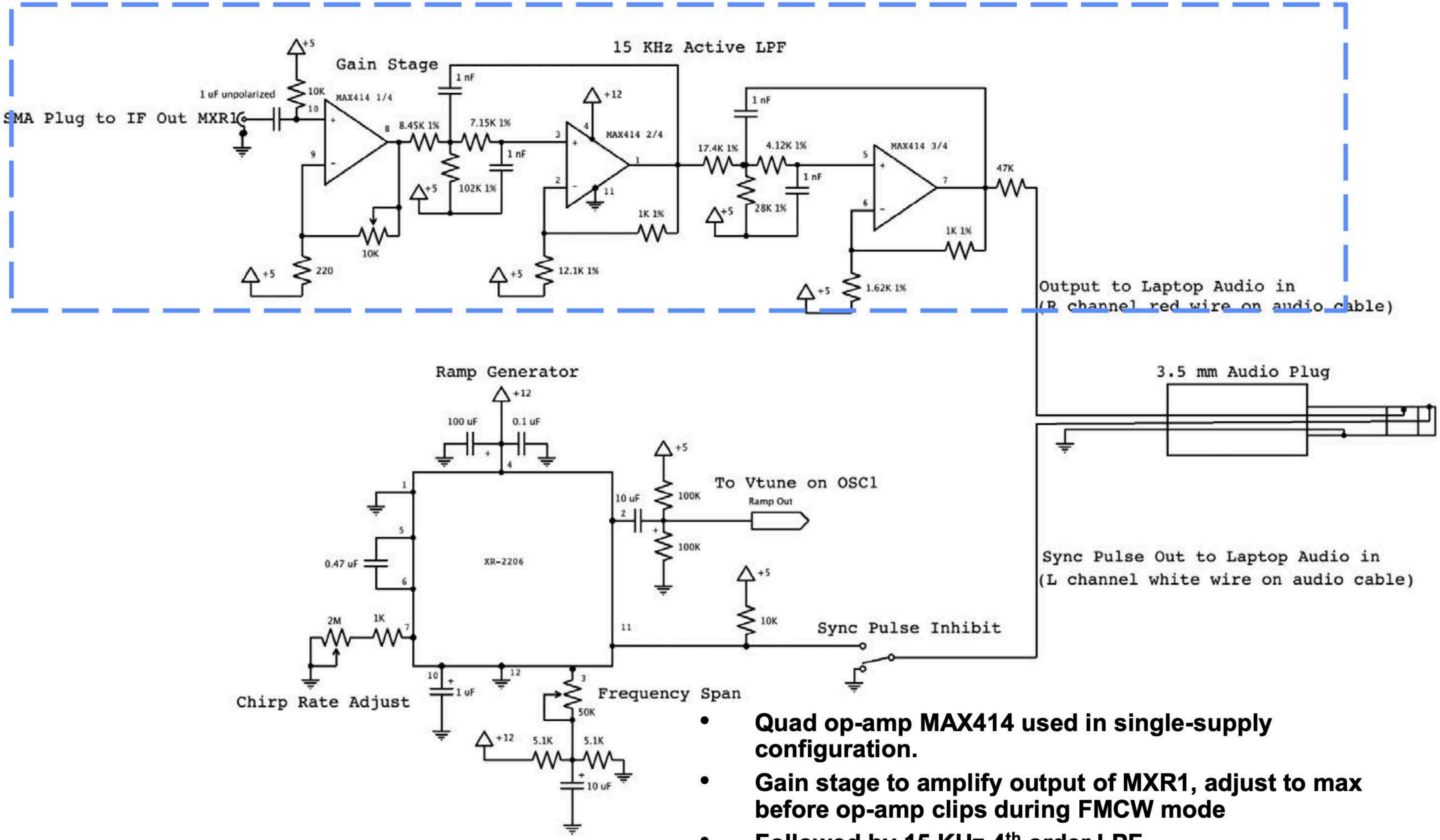


15 kHz Active 2-Stage Low Pass Filter With Gain Stage



https://archive.org/details/donlancaster_afcb

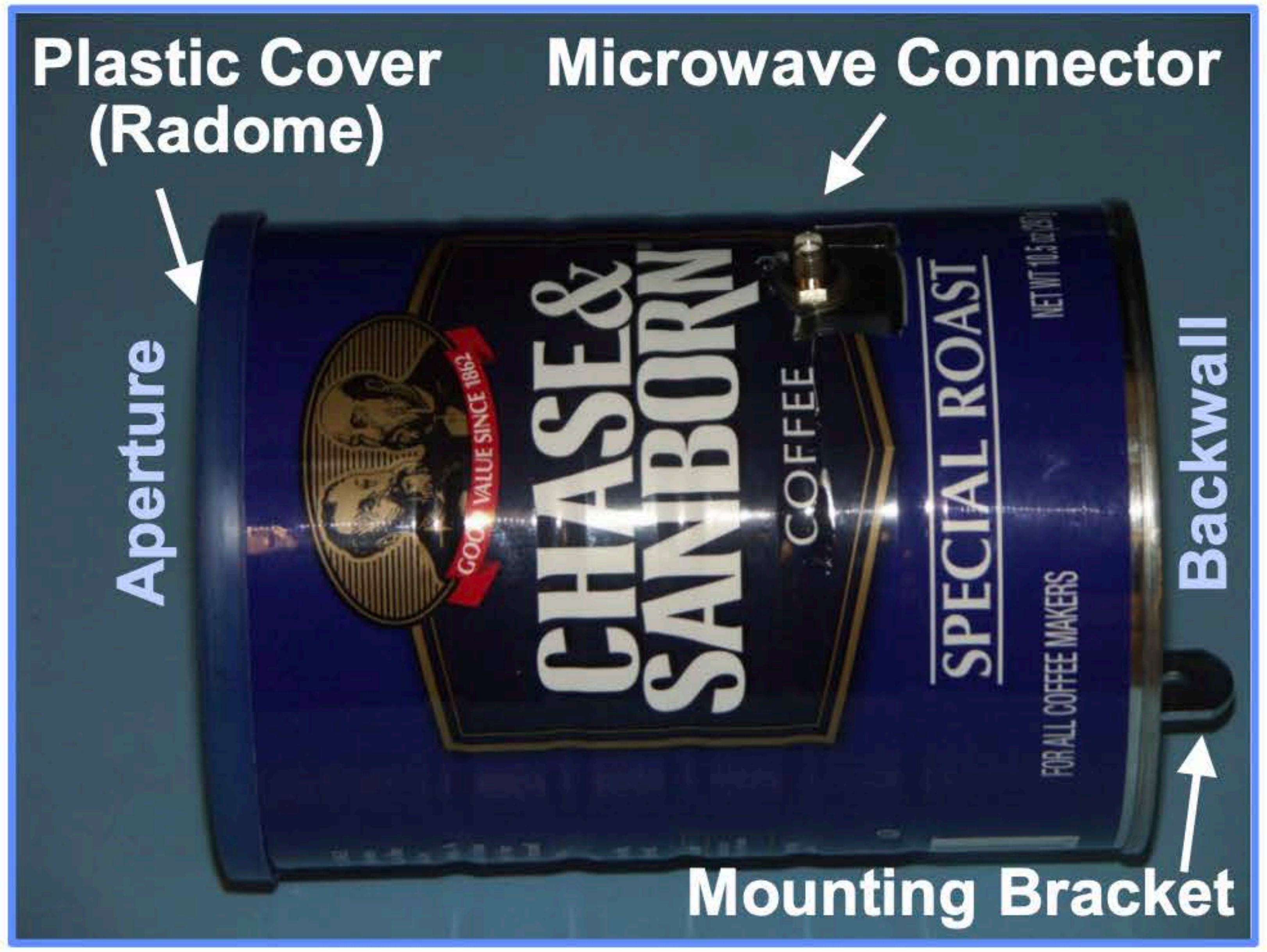
Sallen-Key heritage 4th-order filter
24 dB/octave rolloff

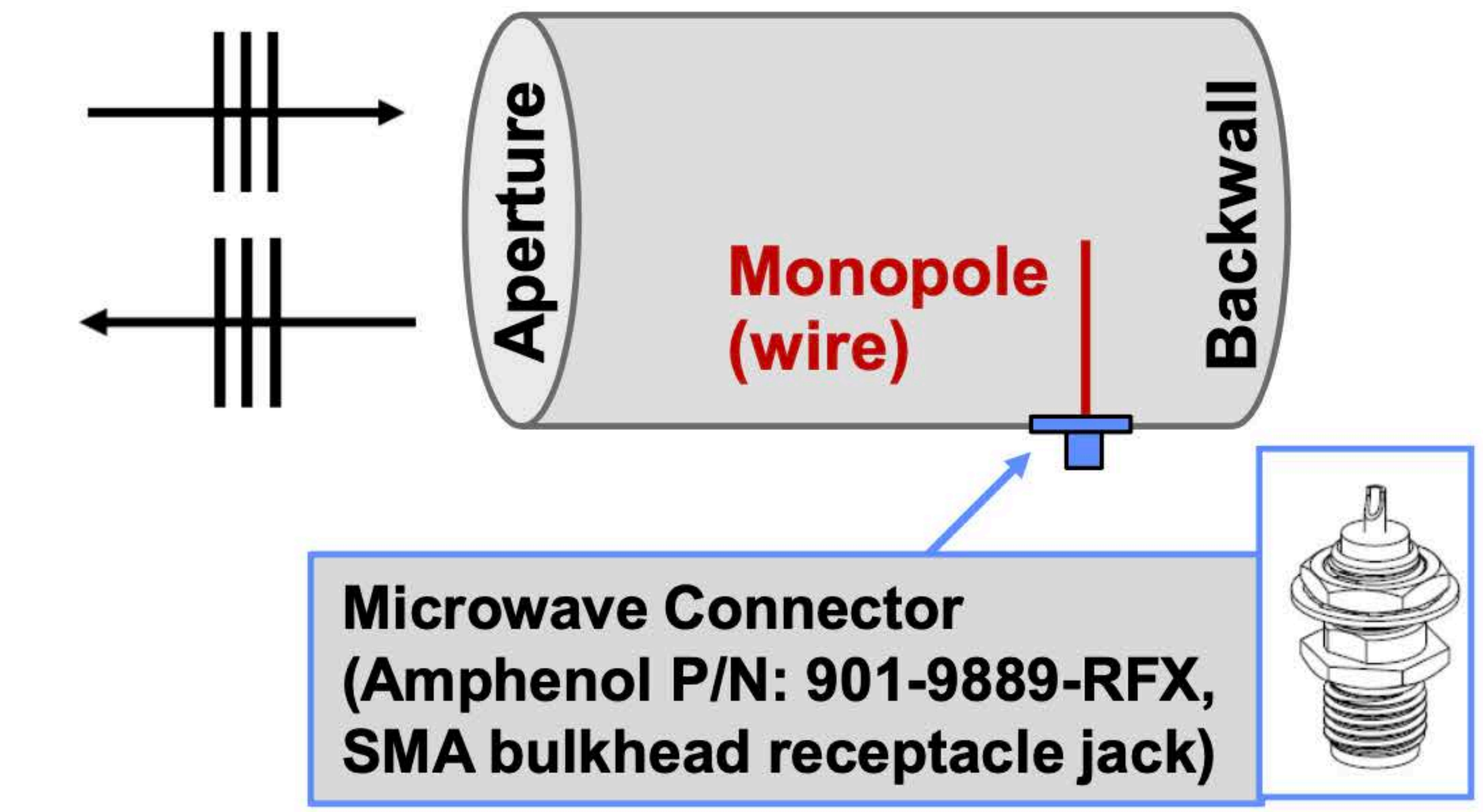


- **Quad op-amp MAX414 used in single-supply configuration.**
- **Gain stage to amplify output of MXR1, adjust to max before op-amp clips during FMCW mode**
- **Followed by 15 KHz 4th order LPF**
  - **prevents aliasing of PC's input audio port**

Example Metal Can Antenna Design for 2.4 GHz

Circular Waveguide Antenna





Coffee can antenna dimensions:

Metal can length = 5.25" (13.3 cm)

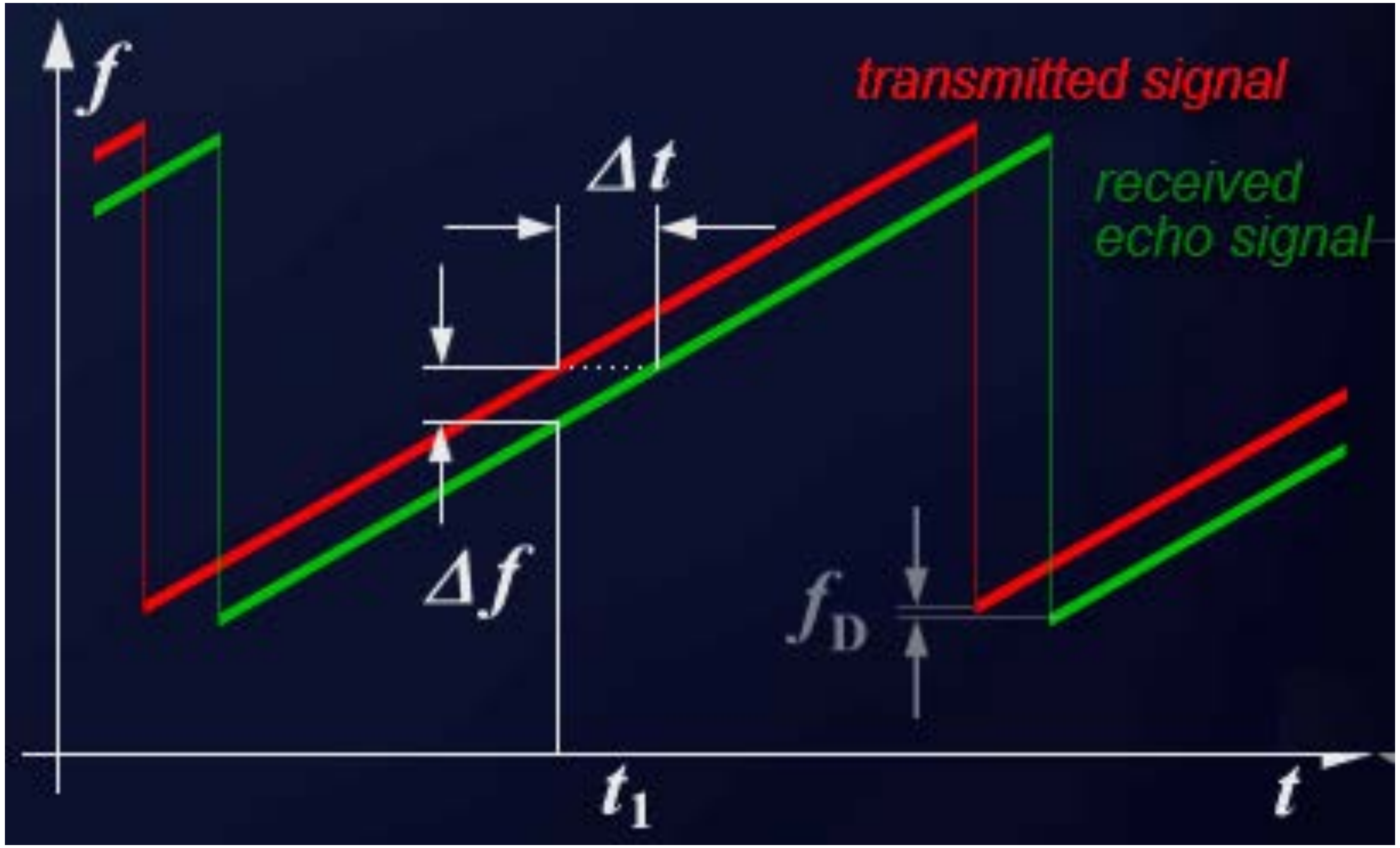
Metal can diameter = 3.9" (9.9 cm) (D=0.8 λ, and λ =4.9" provides a 72.5° HPBW [see Slide 14, Eq. 3])

Monopole wire length = 1.2" (3 cm) (at 2.4 GHz ~ λ /4 in free space)

Spacing from monopole wire to backwall = 1.8" (4.6 cm) (at 2.4 GHz ~λ_g /4 in waveguide – see Slide 20)

Ref: W.W.S. Lee and E.K.N. Yung, "The Input Impedance of a Coaxial Line Fed Probe in a Cylindrical Waveguide," *IEEE Trans. Microwave Theory and Techniques*, Vol. 42, No. 8, August 1994, pp. 1468-1473.

FMCW (Linear Chirp) Radar: Range Determination



https://www.everythingrf.com/community/what-is-a-fmcw-radar

$$TX(t) = \exp(2\pi f(t) \; - k\vec{x})$$

$$f(t) = f_0 + \frac{\partial f}{\partial t}\,(t - t_0)$$

Measured (FFT)

$$R = \frac{c_0 |\Delta t|}{2} = \frac{c_0 |\Delta f|}{2\frac{\partial f}{\partial t}}$$

Note: if the target is moving as well, error in range (range and Doppler are coupled variables for FMCW; we are measuring the **sum** of frequency shift due to range delay and Doppler shift due to velocity)

Velocity of 1 m/s produces error in range of ~7 mm at Small Radar frequencies of ~2.4 GHz using 176 MHz total sweep