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Improved Rover Pointing and 24 GHz QRM

Microwave Update
Oct 4, 2024
Vancouver, B.C.

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- We don’t have:
  - Mountains with accessible vista pull outs
  - Bodies of water more than a few miles long
- We do have:
  - One hill with a view to the area below that is 10 degrees wide and faces West where no one on microwave lives ☺
  - Tall buildings and less taller water towers in Dallas – Fort Worth metro area
  - Flat areas that have breaks in the trees
  - Terrain that falls away slowly for miles
  - Proximity to huge rainstorm cells
  - LOTS of wide-bodied jets from local metro airports
- Does this sound like your area? What parts do you have and not have?

Hope is not lost

- Smaller bodies of water are usable as a DX path at very high frequencies (122 GHz) see NTMS paper “Conquering Lake Lavon”
- The one hill – Cedar Hill - has been used to achieve:
  - 122 GHz DX of 17 km
  - Laser 2-way contact of 27 km
- Cedar Hill has 12 towers used successfully at 10 & 24 GHz for tower bounce (< 50 km DX) when direct path was blocked
- Water towers have provided interesting experiments if you are LOS
- Tall buildings have enabled 10 & 24 GHz contacts otherwise not possible.
- Normal good DX via rain scatter (like other North America areas)

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Rover Reality

- In general, the rover will be in the sticks.
- The rover will operate from virtually ground level.
- The rover will usually be alone with few exceptions.
- The rover cannot see (is not LOS) to a water tower or tall building.
- The rover will attempt a contact with a fixed station equipped with a dish on a tower.
- The rover will attempt a contact with another rover or a portable.
- The rover will face distraction by passers by, farm animals and insects.
- To avoid frustration, the rover needs to have a clear plan.

The Plan (do the homework)

- Location, location, location
- High ground, falling away terrain in the path of the signal
- Very little or no foliage for first 1000 meters
- Verify access to the location
  - Is it located on a right-of-way?
  - Is there automobile traffic?
    - Light versus heavy (be aware of 24 GHz QRM)
  - Are you prepared to meet the land owner?

Pointing accuracy

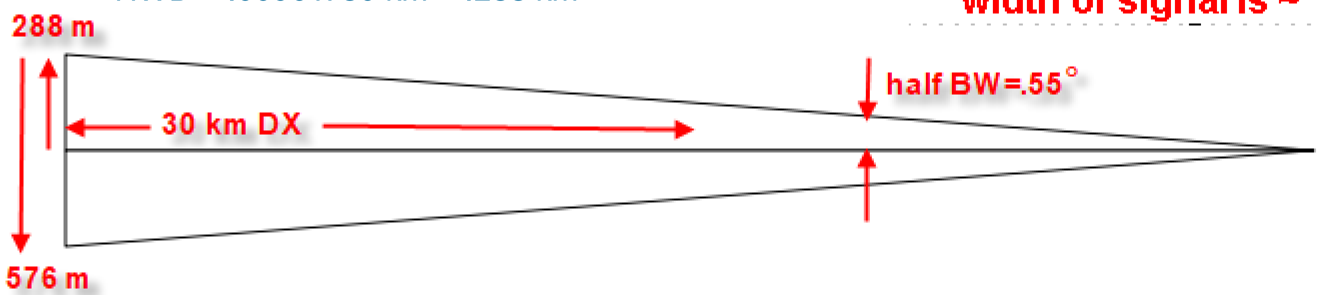
- Dish 3 dB beamwidth:
  - θ ≈ 70 * (λ / D)
  - 24 GHz dish = 76 cm so θ ≈ 70 * (1.2 cm / 76 cm) so θ ≈ 1.1 °
  - 47 GHz dish = 45 cm so θ ≈ 70 * (.6 cm / 45 cm) so θ ≈ .9 °
  - SohCahToa – solve for Opp – call it HWD half beam width distance
  - At 30 km the 3 dB beamwidth is:

tan(0.55 °) = HWD/30 km

rearrange: HWD = tan(0.55 °) x 30 km

HWD = .0096 x 30 km = .288 km

In this calc, at 30 Km the 3dB width of signal is ~ 1/2 km



More to scale:

Pointing accurately - K7FRY

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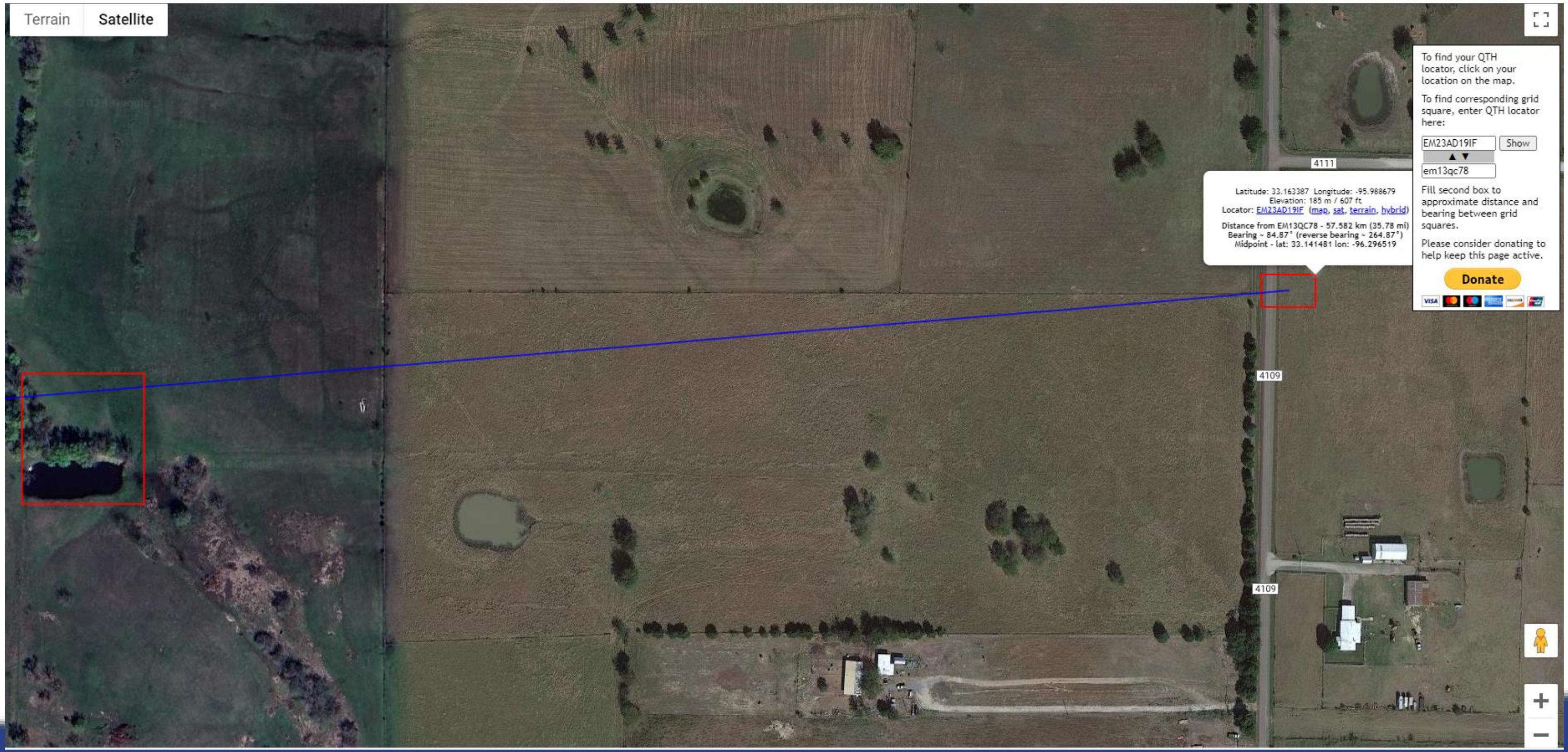
- K7FRY.com accepts a single or double set of grids (up to 10 characters)
  - This is your ***primary trusted data***. From this you will extract landmark(s).
  - Bearing is displayed by this tool as 264.87 degrees, say 265 ***TRUE***



Pointing accurately - Terrain

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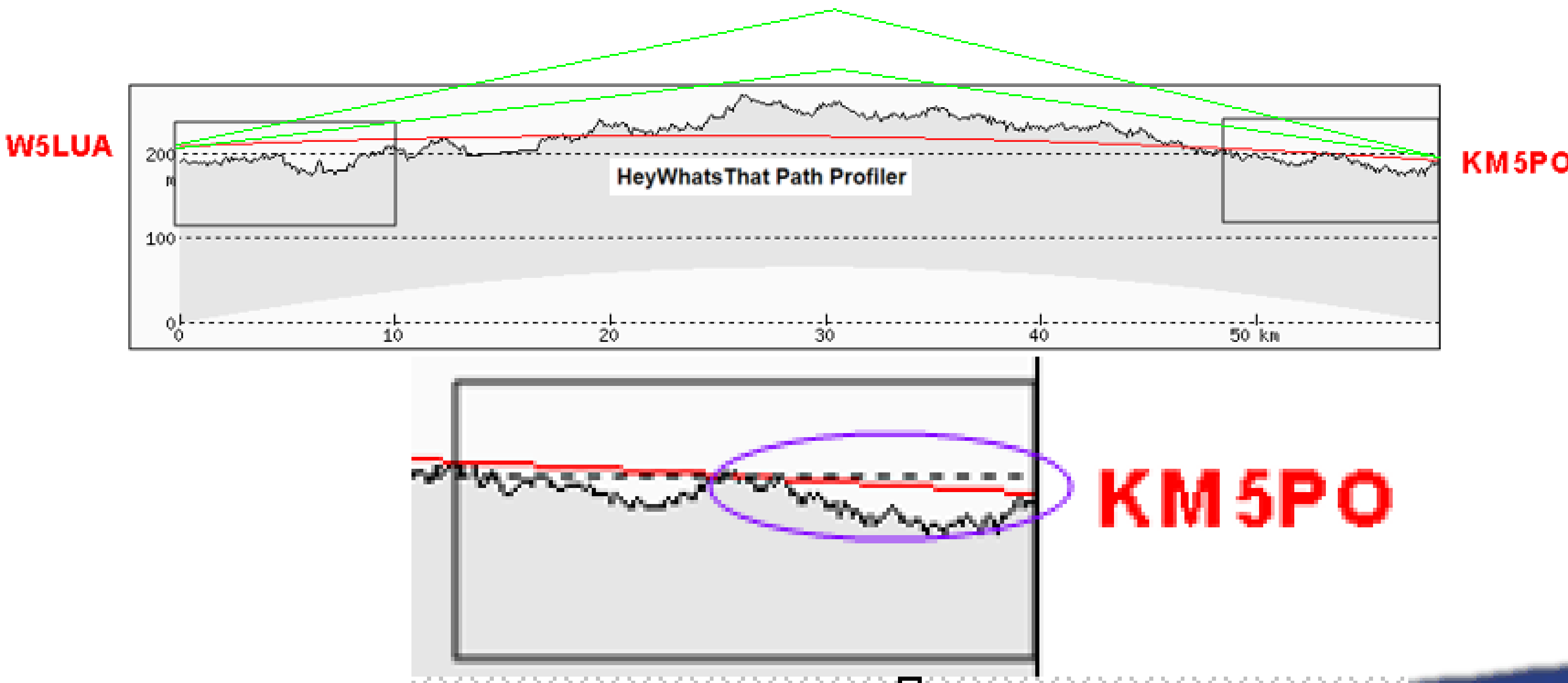
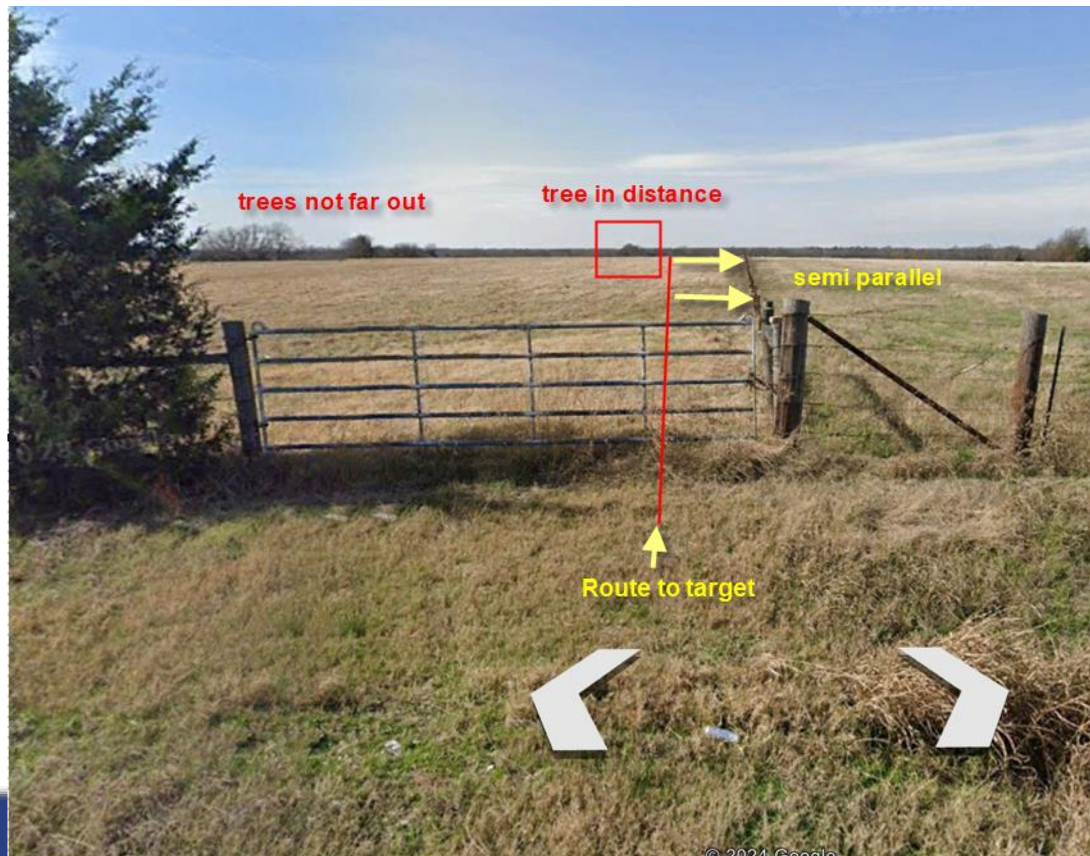
- Note that there is good “takeoff” on both ends
- Terrain is falling away fast on the rover side making the landmark appear more distant or slightly below the near horizon



Pointing accurately - Landmark

- Set a very accurate line in Google from your location to target
- Correlate street view to K7FRY to locate suitable landmark

Google's street view after setting route line from your location to the target



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Pointing accurately - Landmark

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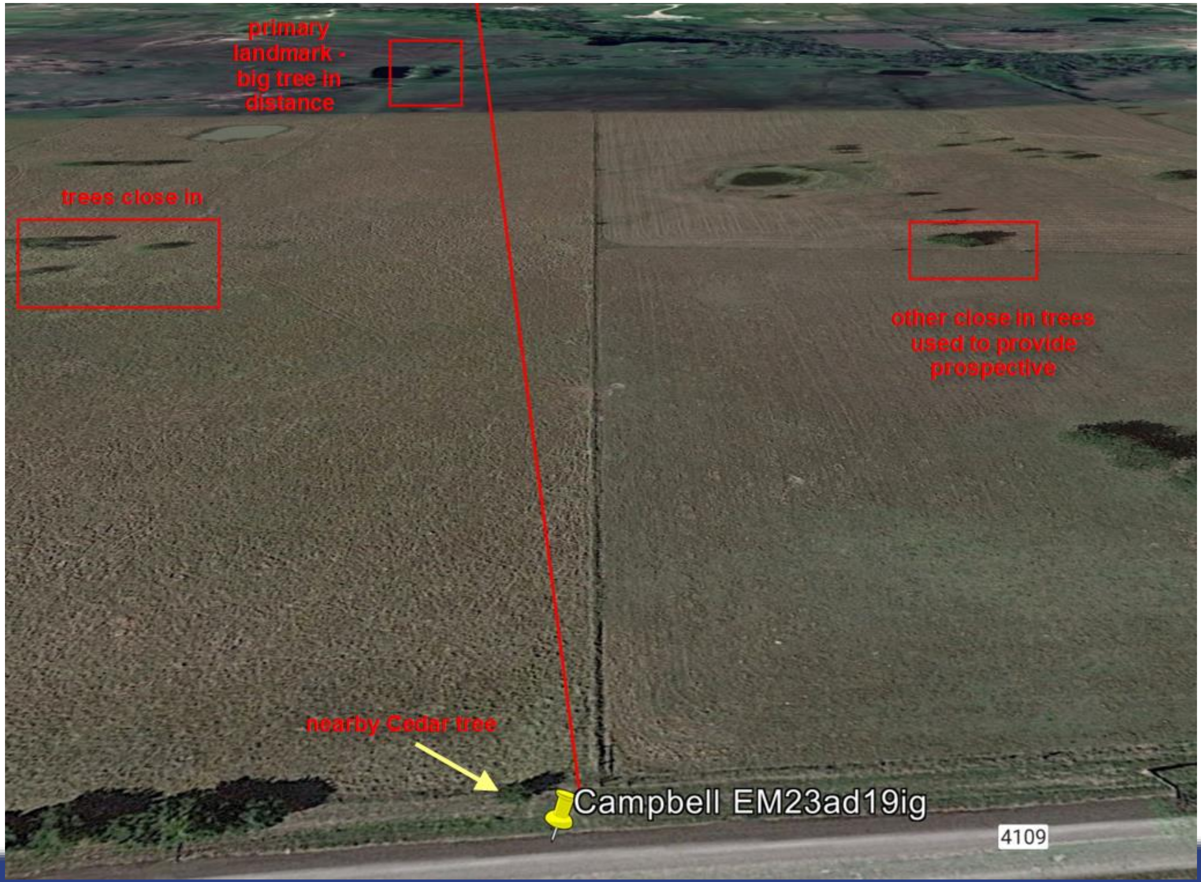
- Use Google maps to tilt view to verify landmark(s)



Pointing accurately - Landmark

- Find landmark when you go to location

This resulted in a successful 47 GHz qso at 60 km. Signals were 569

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Theodite phone app

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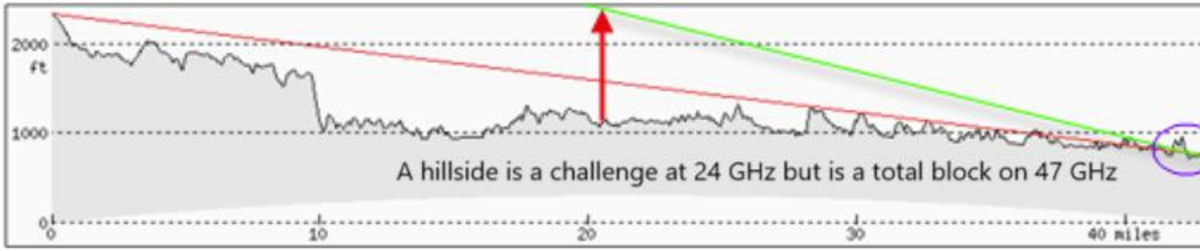
- Theodite iphone app – game changer
- Combines augmented reality for measurement, bearings (True and Magnetic) plus GPS/Grid, maps, 2 axis inclinometer.
- The “RED DOT” is your friend (and target for aiming).
- View through camera can be zoomed to 4 x.

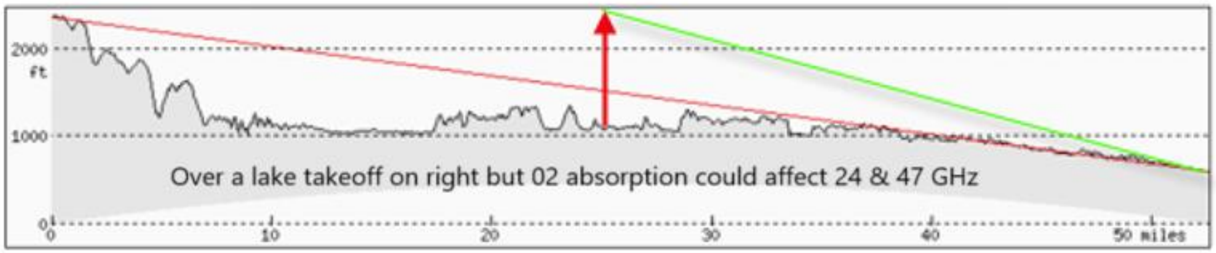
Betting odds



10 GHz 100%

24 GHz <50%

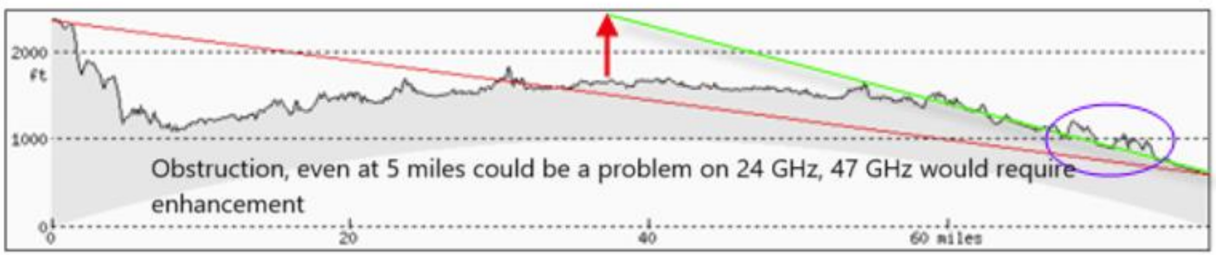
47 GHz ~ 0%



10 GHz 100%

24 GHz 100%

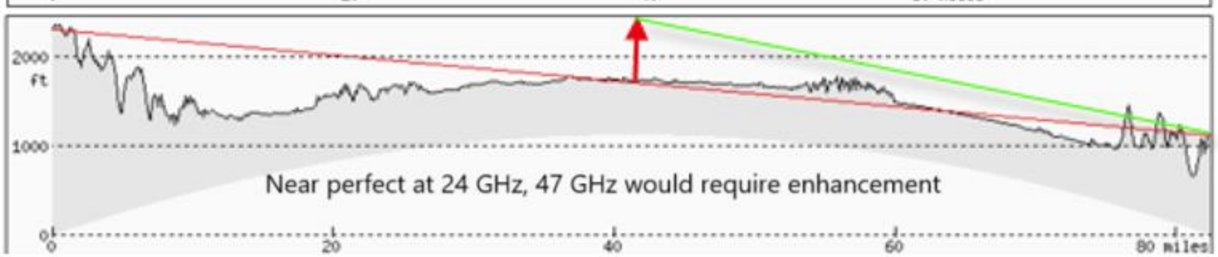
47 GHz >50%



10 GHz 100%

24 GHz <50%

47 GHz ~ 0%



10 GHz 100%

24 GHz >80%

47 GHz ~ 0%

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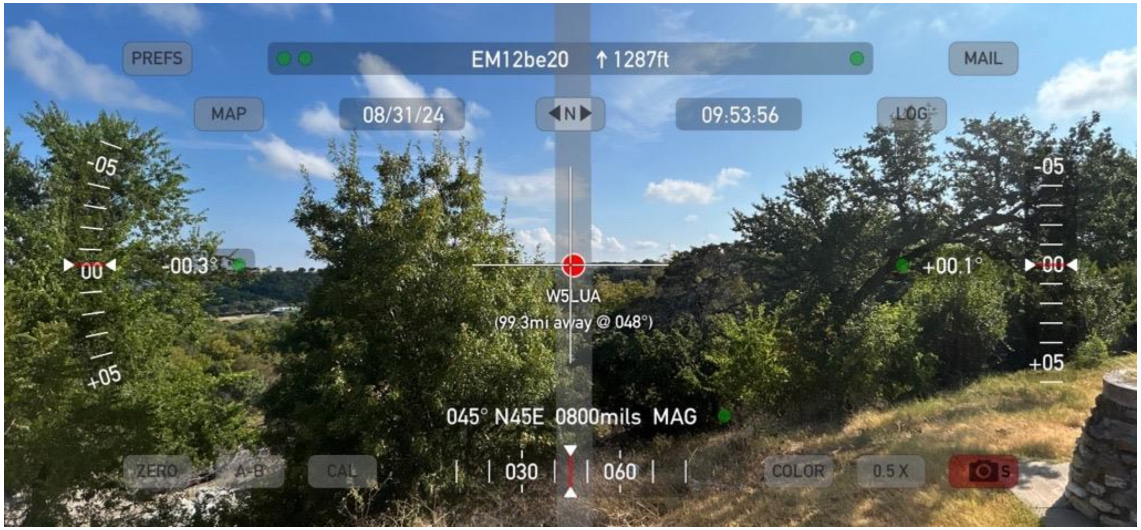

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Betting odds

Steps to success

- Review location and pick landmarks via K7FRY
- Review path profile in heywhatsthat profiler
- Find landmarks in Google street view
- Elevate the google route view of landmark
- Does all data correlate?
- Place your target in Theodite and use the red dot when on site
- Be prepared to use a compass with deviation correction if your other technology fails.

24/47/122 GHz Rover operation

- 10/24 dual band feeds
    - Peak on 10, switch to 24
    - Peaking by finding the first null on both sides then split the angle
- Separate 10 & 24 & 122 dishes – parallel edges!
- 24/47 and 24/122 feeds on same offset dish
    - Peak on 24, switch to 47 or 122.
    - Best if 24 GHz signal is weak!
    - Use a closely mounted (24 GHz) Vivaldi in horizontal polarization next to 47 GHz feed. Integrate Wavelab XN low cost module for 24 GHz receive only.

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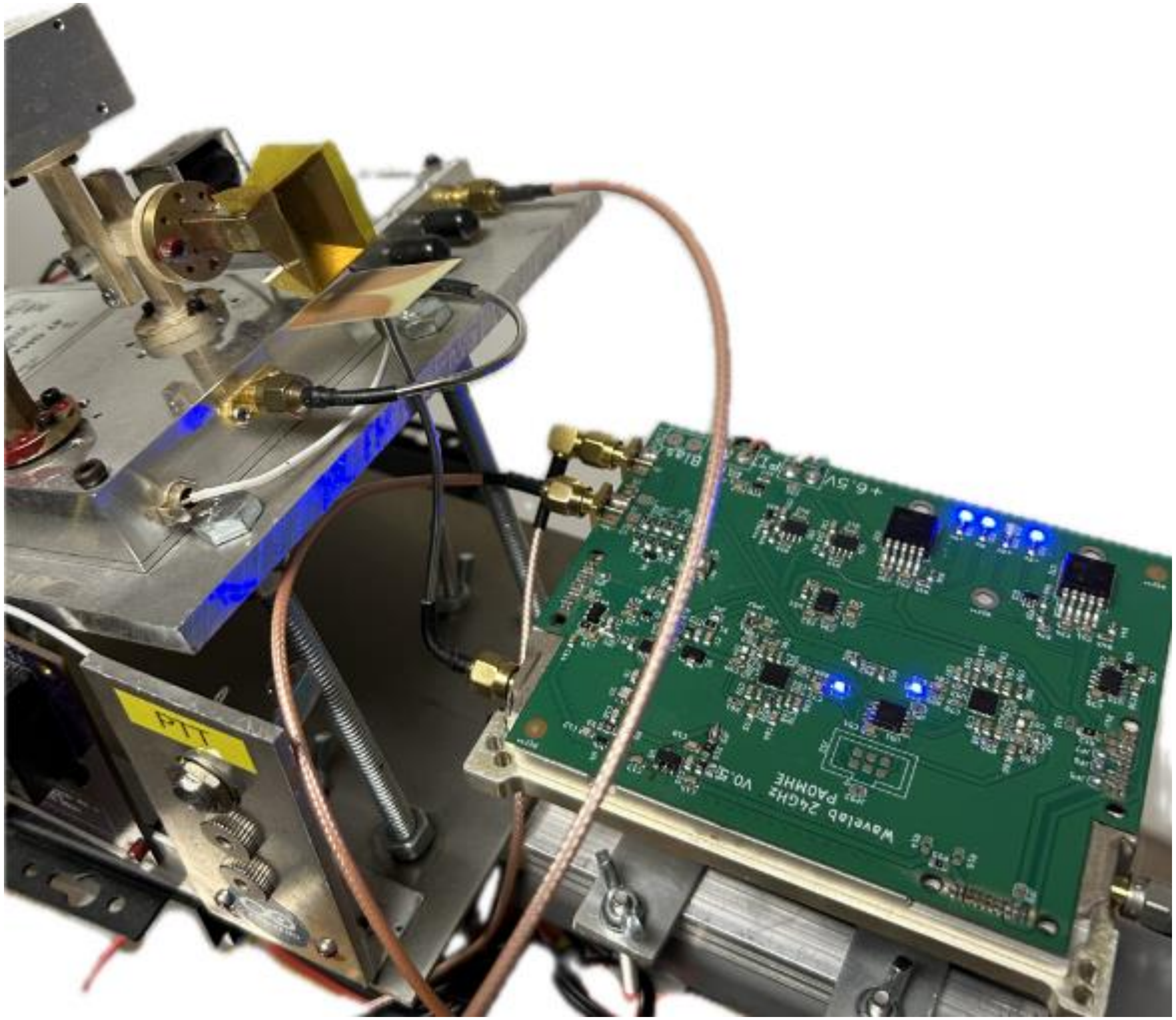
24 GHz used with 47 GHz



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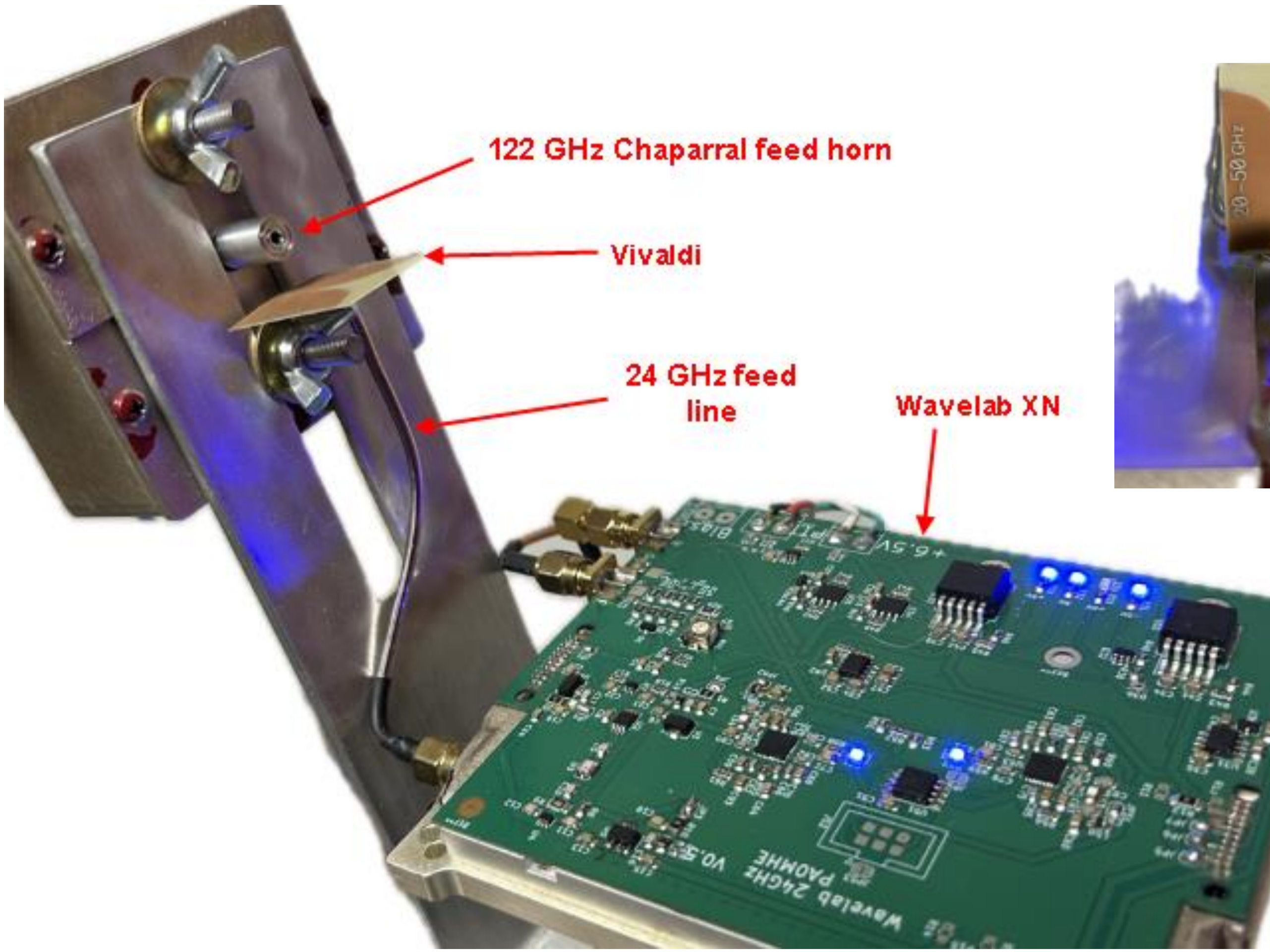
24 GHz used with 122 GHz



24 GHz QRM

- 24 (24.050 – 24.250) GHz is shared with:
  - Part 15 “RF Devices” *Field Disturbance Sensor*
  - Part 18 “ISM Equipment”
  - Part 90 “Private Land Mobile”

eCFR :: 47 CFR Part 15 -- Radio Frequency Devices

eCFR :: 47 CFR Part 18 -- Industrial, Scientific, and Medical Equipment

eCFR :: 47 CFR Part 90 -- Private Land Mobile Radio Services

QRM at W5LUA looking 38 degrees

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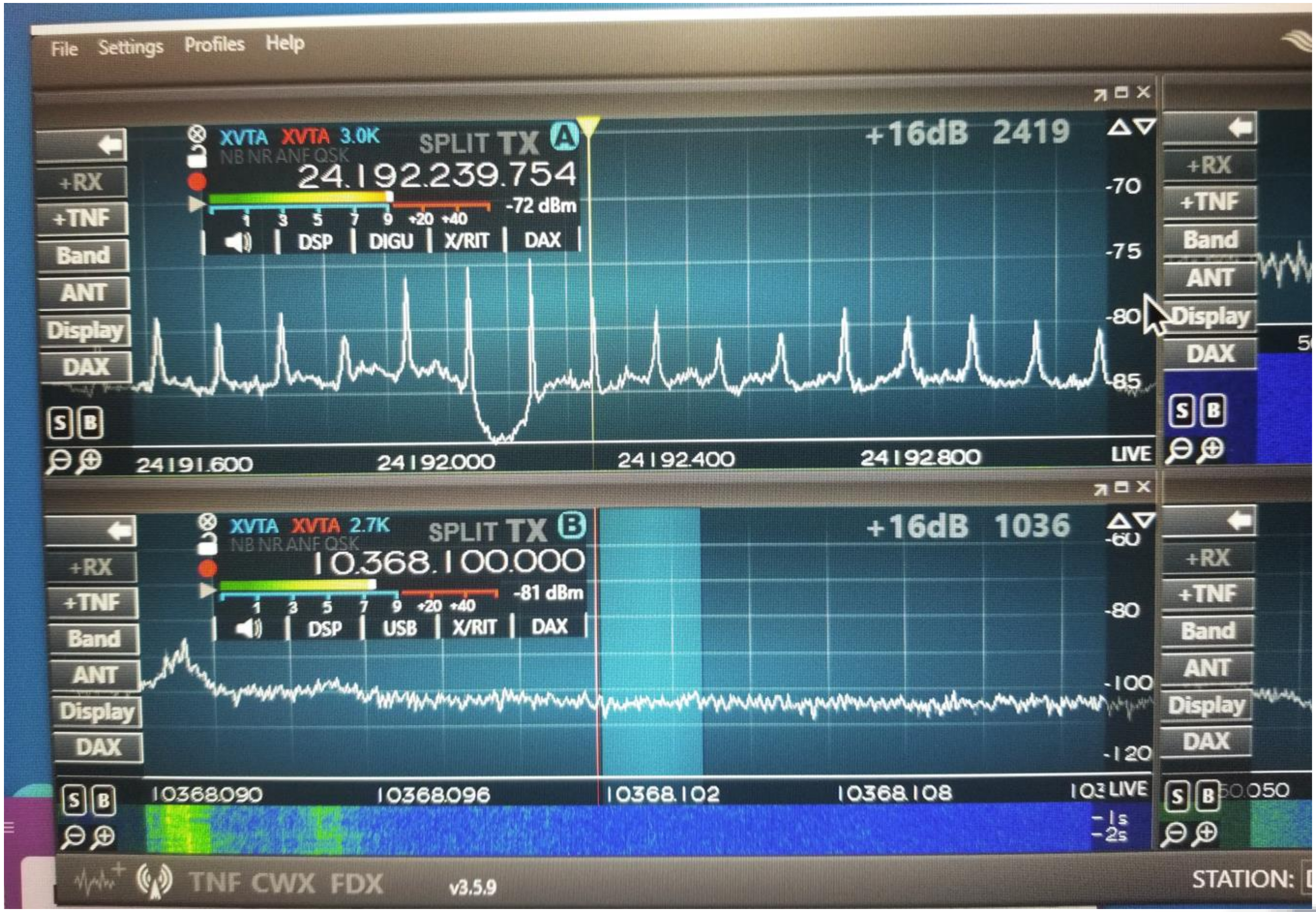


The 24 GHz Dir Find team

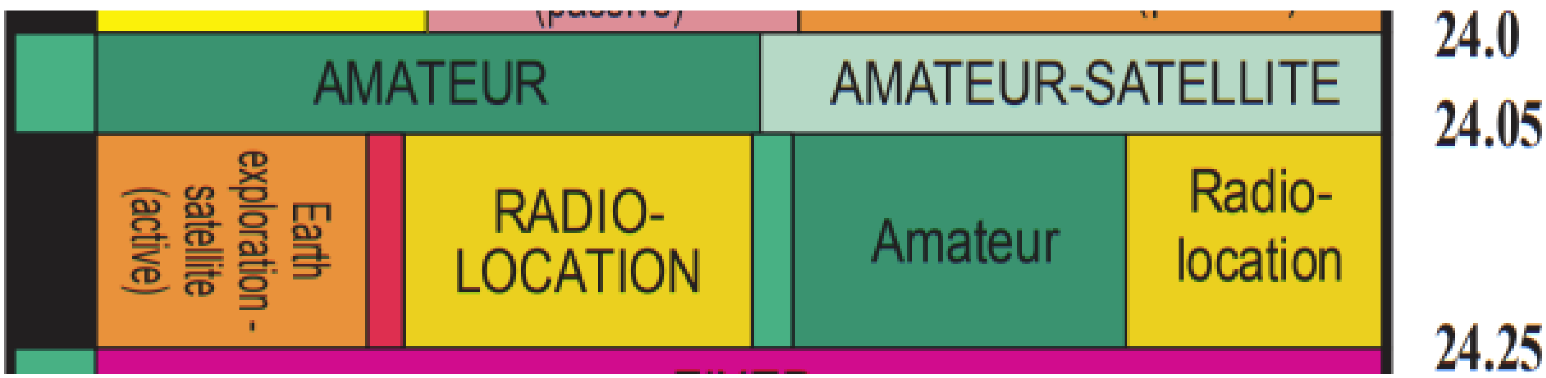
Matthew Kube W5ZCA and Richard Burger AG5XW

24 GHz Wavelab sniffer in foreground

Shared 24 GHz spectrum

Table of Frequency Allocations — 18.6-24.45 GHz (SHF) — Page 53

International Table	United States Table		FCC Rule Part(s)
24-24.05 AMATEUR AMATEUR-SATELLITE 5.150	24-24.05 5.150 US211	24-24.05 AMATEUR AMATEUR-SATELLITE 5.150 US211	 ISM Equipment (18) Amateur Radio (97)
24.05-24.25 RADIOLOCATION Amateur Earth exploration-satellite (active) 5.150	24.05-24.25 RADIOLOCATION G59 Earth exploration-satellite (active) 5.150	24.05-24.25 Amateur Earth exploration-satellite (active) Radiolocation 5.150	 RF Devices (15) ISM Equipment (18) Private Land Mobile (90) Amateur Radio (97)



Signal identification

"The" reference for signals is- but lacks the higher bands..
https://www.sigidwiki.com/wiki/Signal_Identification_Guide

From the reference signal page above, this modulation sounds close to what we heard in Al Ward's case: OTH-SW Chinese over the horizon radar
https://www.sigidwiki.com/wiki/Special:RunQuery/Database

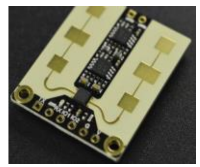
The Gov/FCC frequency allocation schedule
https://transition.fcc.gov/oet/spectrum/table/fcctable.pdf

Gov/FCC colored wall chart
https://www.ntia.gov/page/united-states-frequency-allocation-chart

Two DUTs

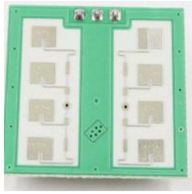
Two common 24 GHz “human presence” radar units were tested.

DfRobot SEN0395



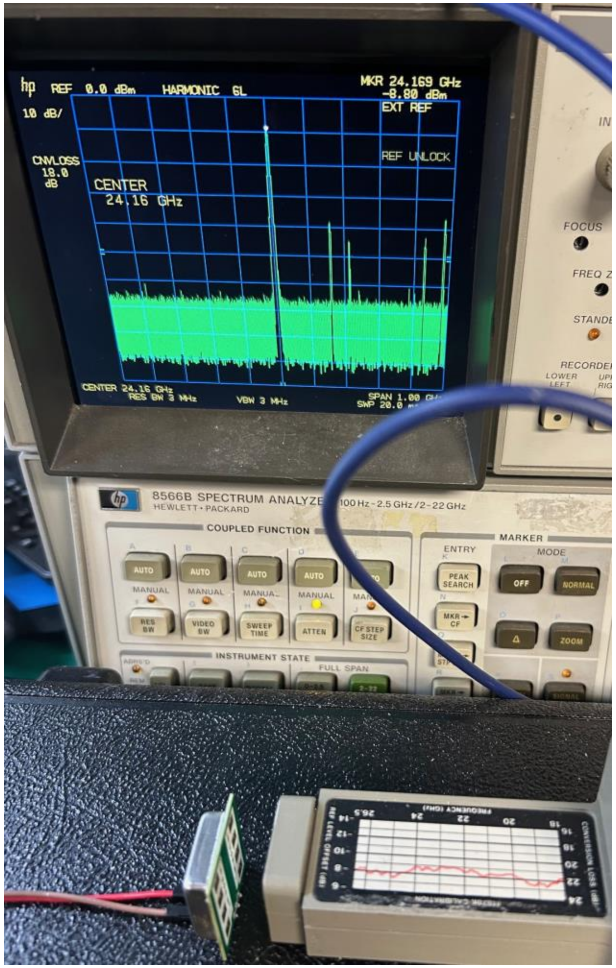
Parameterl	Value
Freq	24.125-24.250
Oper V	3.6-5v
Oper Cur	90 mA
Modulation	FMCW,CW
Pwr output	13-15 dBm
IF	uProc serial

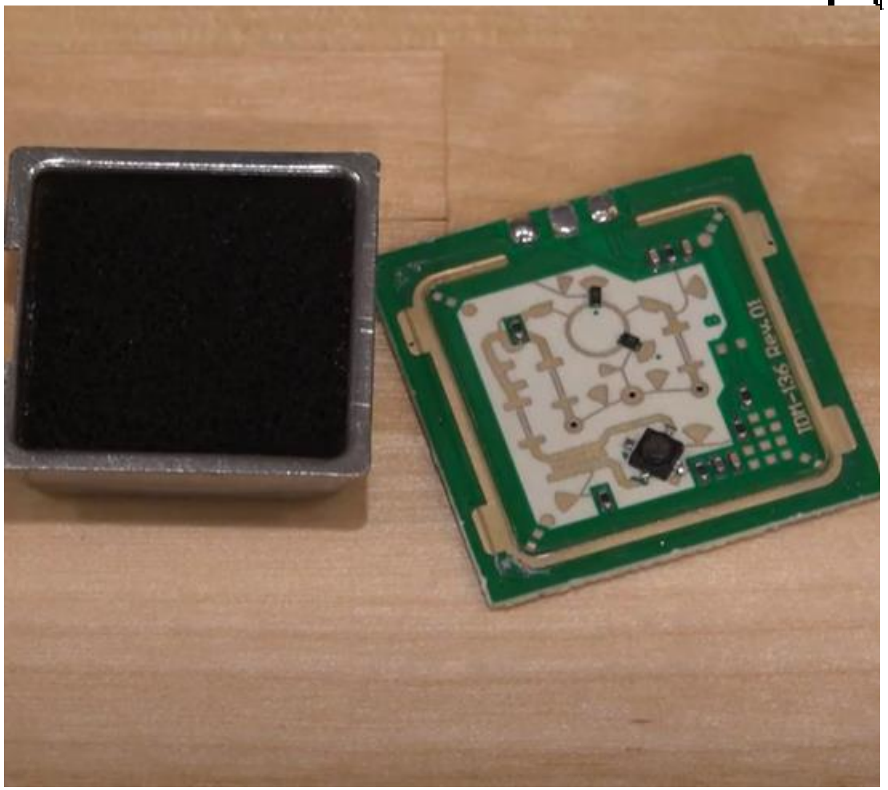
CDM 324



Parameter	Value
Freq	24.125-24.250
Oper V	5.5v
Oper Cur	30 mA
Modulation	CW pulse
Pwr output	16 dBm
IF	-300 to +300 mV

CDM 324





https://www.youtube.com/watch?v=5vqSX40seqA&t=173s

DfRobot SEN0395

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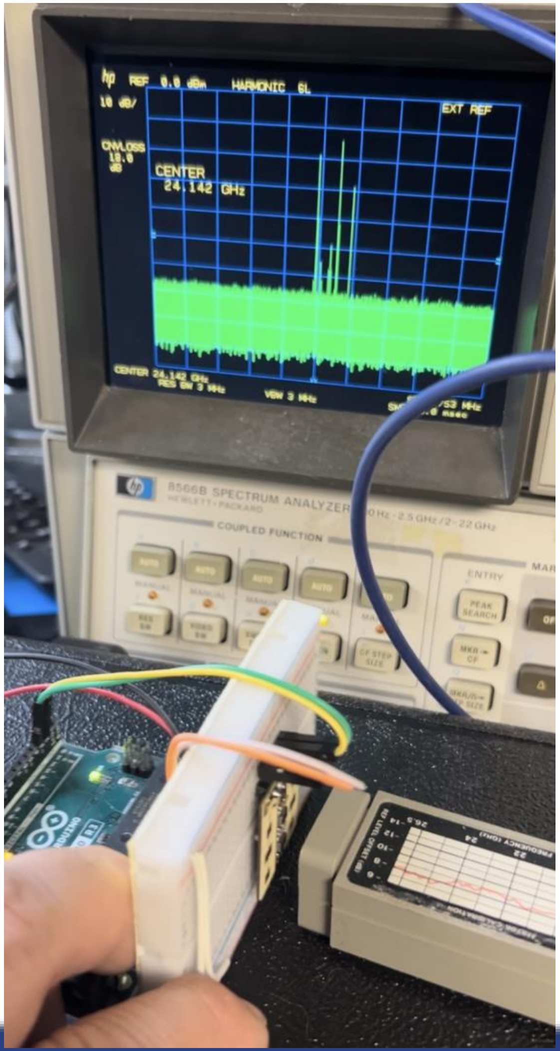
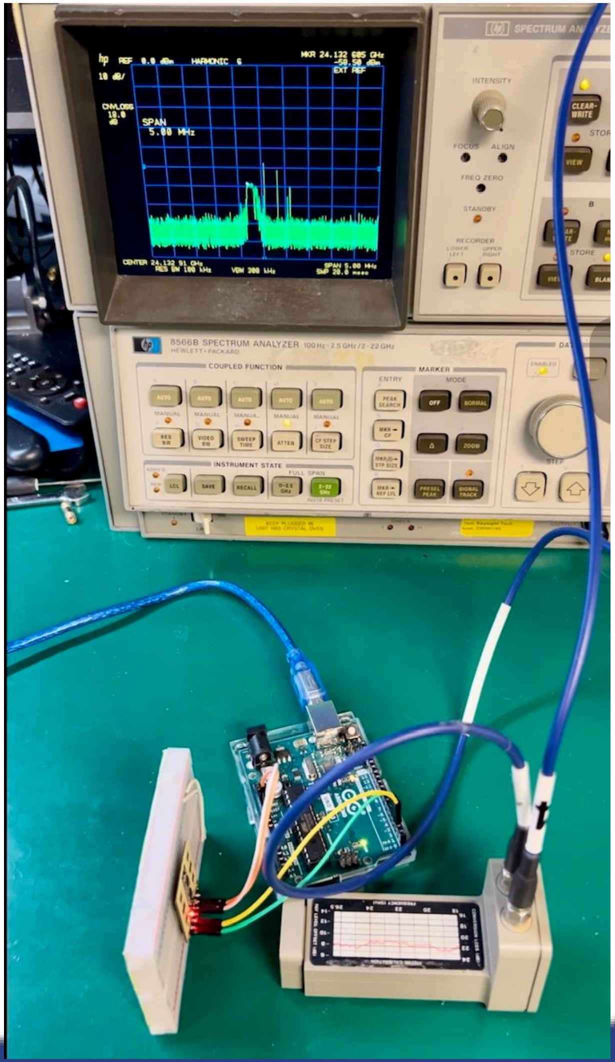
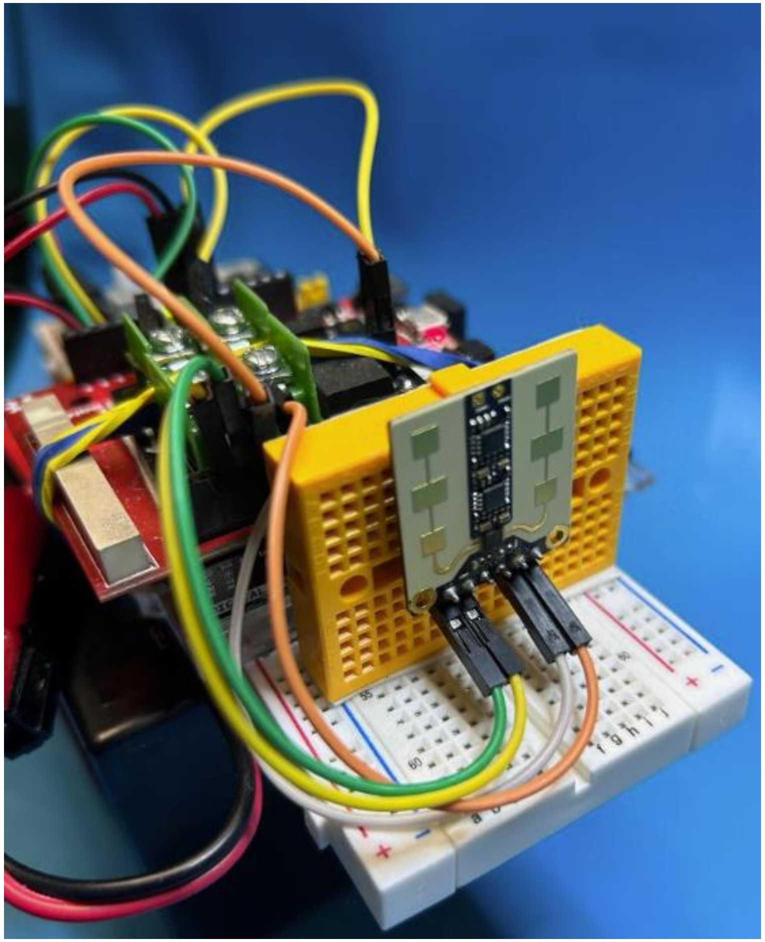
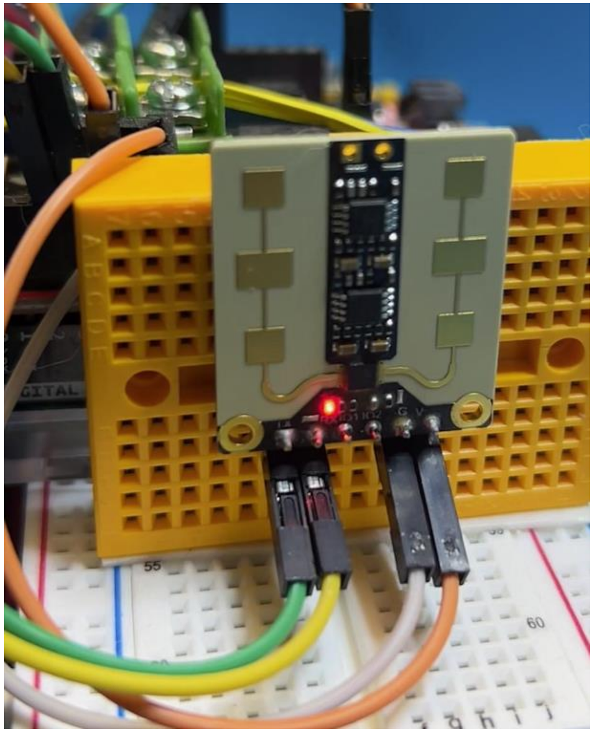




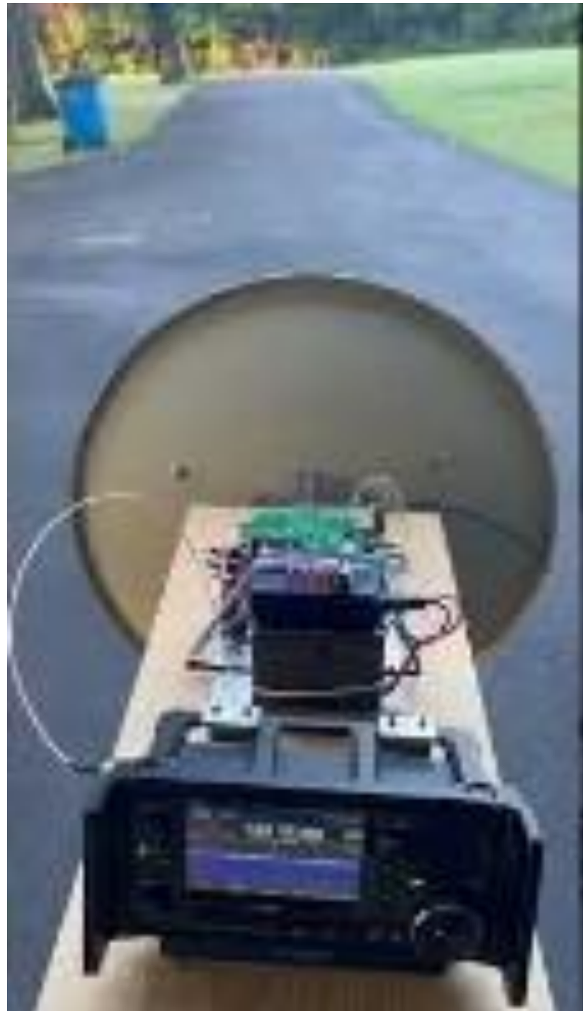
DfRobot SEN0395





QRM generator remote controlled via Halogram cell connectivity

SEN0395 Wide Band signal



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Noise blanker – Noise reducer effectivness

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24 GHz QRM

- What we know
  - 24 GHz proximity alert devices are showing up *on the doorstep*
  - 24 GHz and now 77 GHz is a multi billion dollar industry in the ADAS sector alone
  - 24 GHz also includes the ISM band from 24.0 to 24.250 (TI calls this the “narrow band”)
  - 24 GHz includes an ultra wide band which is 5 GHz wide

24 GHz QRM

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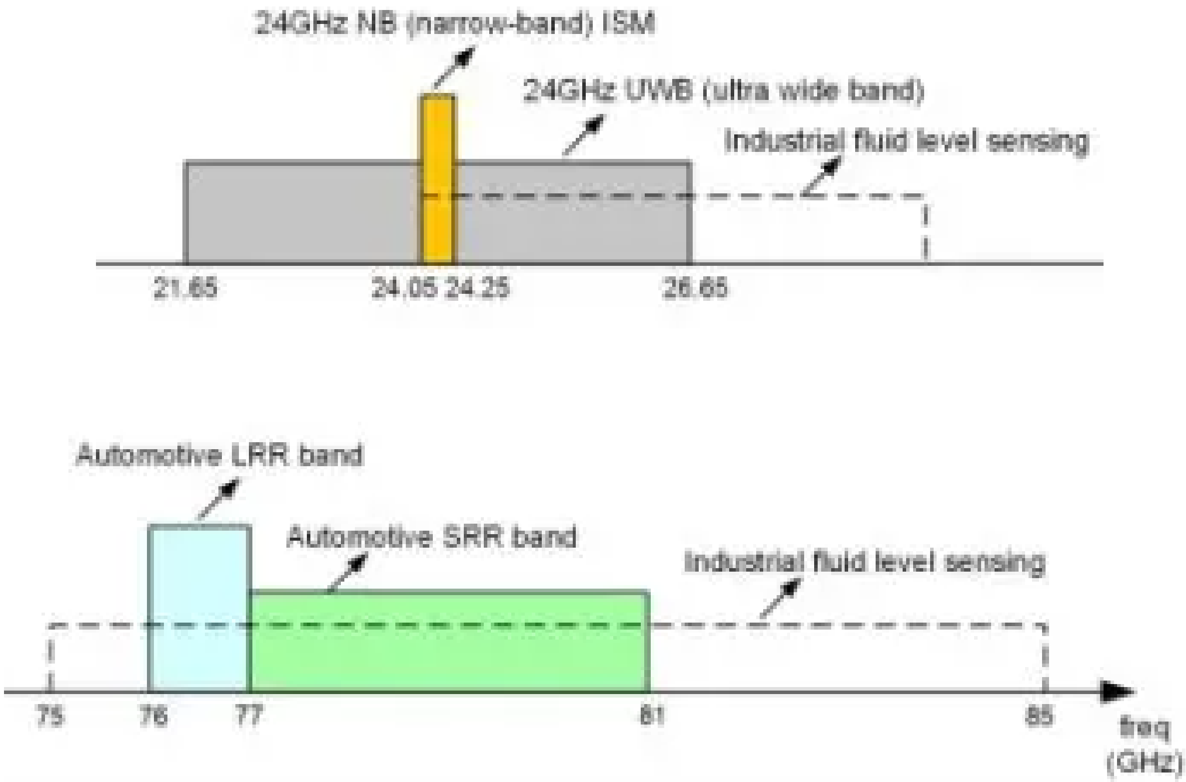

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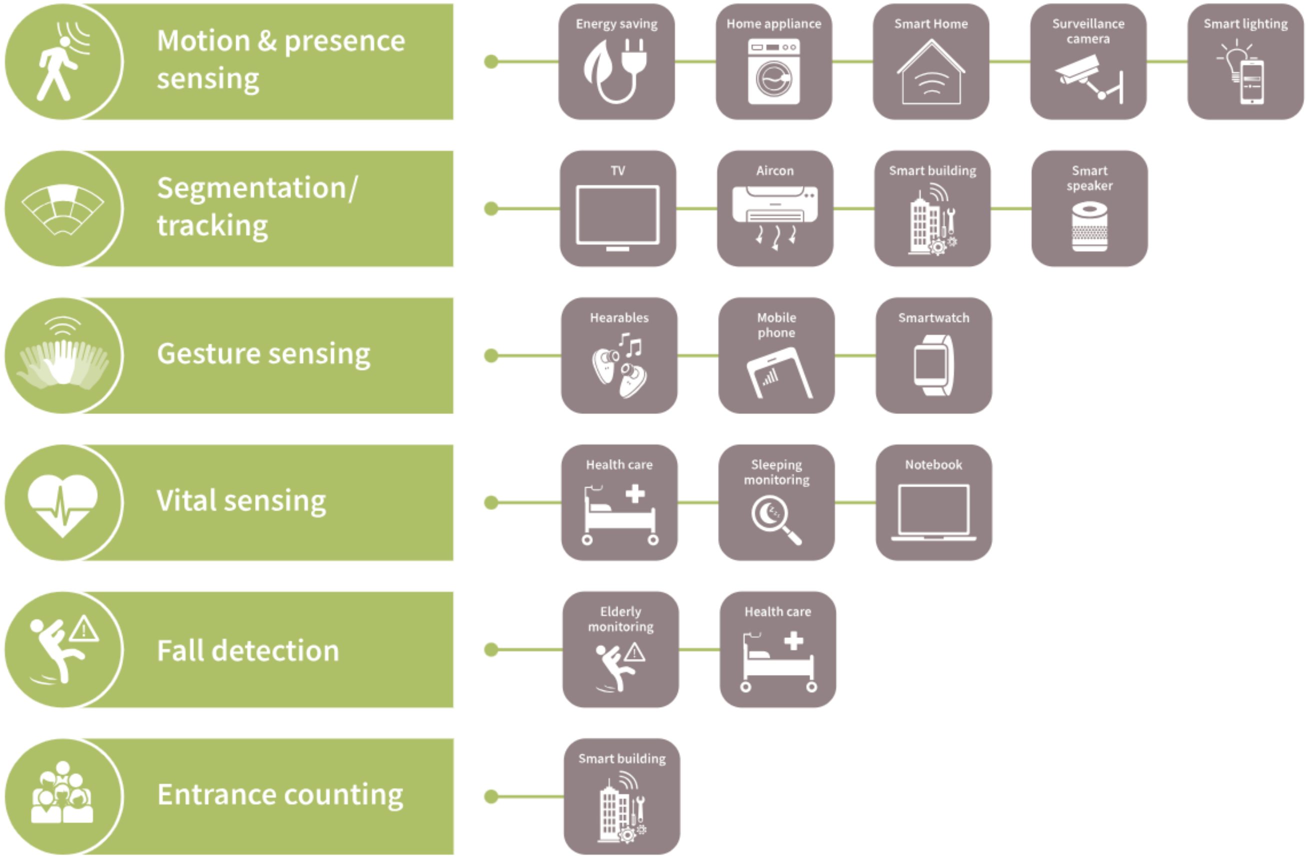
Infineon standardizing the API

Benefits of Ripple™

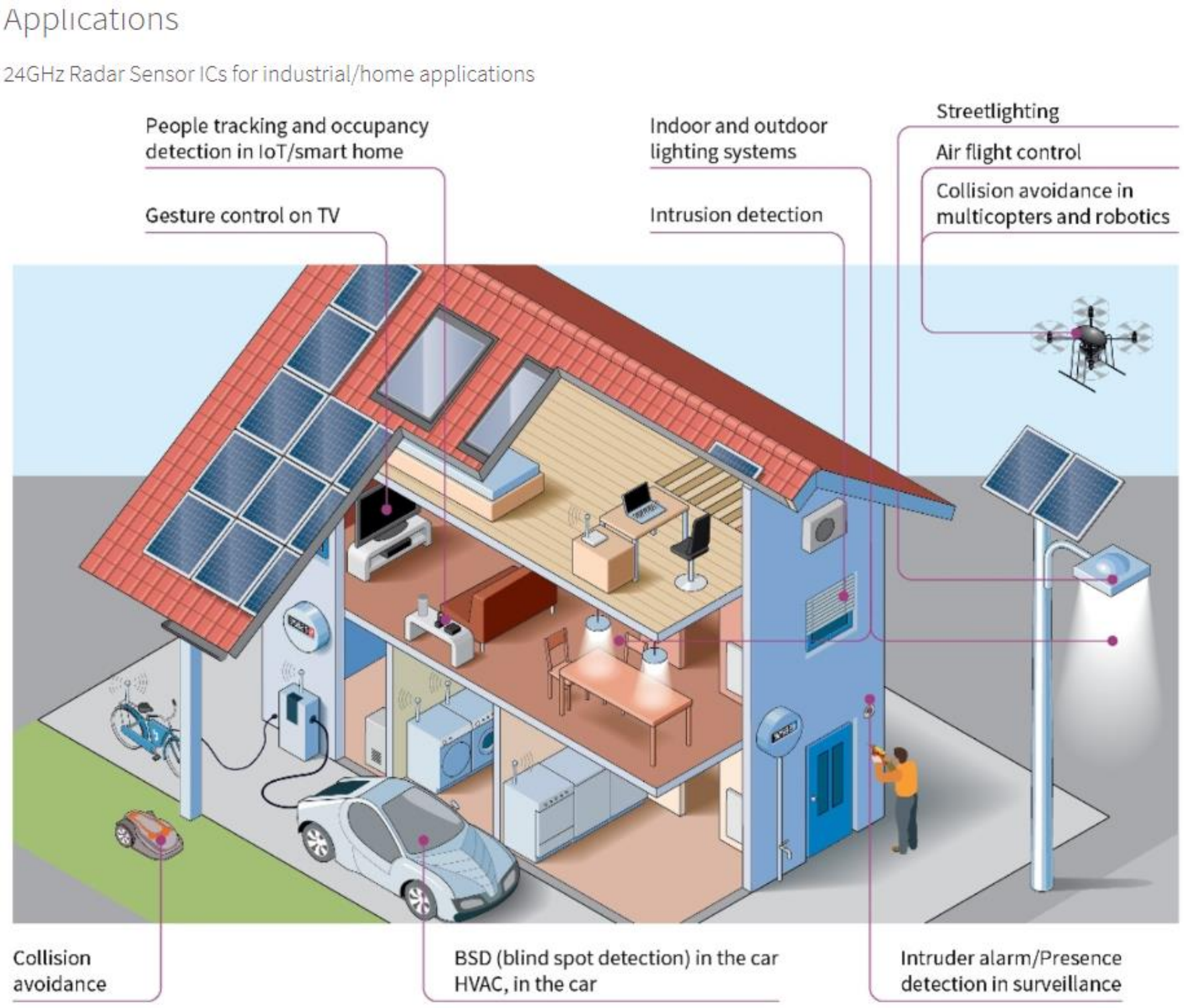
Ripple™ benefits

- **Interoperable software libraries** — Thanks to standardized calls, software libraries can work across various radar hardware implementations, ensuring reusability, and easier firmware upgrades.
- **Growth of radar hardware ecosystems + integrators** — With an open API standard, it's easier for integrators to get started, develop, and distribute radar solutions. → Reduced barrier to entry will lead to new products and services for consumers.
- **Innovation & differentiation with extensions** — Enablement of developers to create specialized extensions so that they can build on the standard to support their own differentiated use cases.
- **Education & academic research** — Standardized software across all radar applications to simplify experimentation and prototyping, making radar technology more accessible to students, startups, academics, and researchers.

Some uses (from Infineon)



Applications



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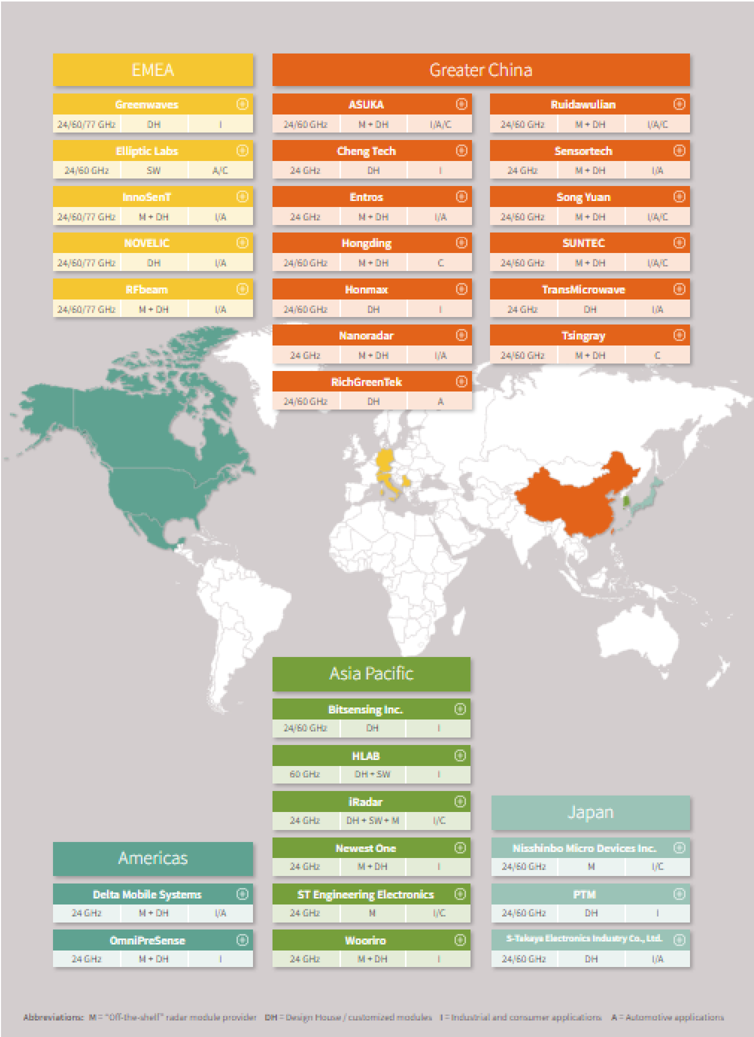
Just a few of the vendors

Radar partner ecosystem at a glance including design house partners



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Few more vendors

Manufacturer	Part	Freq	Output
Infineon Technologies	BGT24ATR11	24.0-24.25 GHz	11 dBm
Analog Devices	ADF5901	24.0-24.25 GHz	8 dBm
STMicroelectronics	STRADA431	24.0-24.25 GHz	13 dBm
AutoLiv	Various	24.5 but 1GHz UWB	10 dBm
Calterah Semiconductor	Various	Moving to 60/77 GHz for “$10B” market - 2024	

24 GHz QRM

References:

Texas Instruments (above 24 GHz) Automotive mmWave radar sensors | TI.com

Analog Devices (ADF5901) ADF5901 Datasheet and Product Info | Analog Devices

Infineon 24GHz radar sensors - Infineon Technologies

DfRobot mmWave Radar - 24GHz Human Presence Detection Sensor (9 Meters) - DFRobot

Questions?

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