

RADARS and RADAR SPECTRUM ENGINEERING CRITERIA (RSEC) A Comprehensive Introduction and Review

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September 26, 2019



Question

Did you use personally use a radar today, or in the past few days or weeks?...maybe not directly but consider this....radars have lots of applications that sort of run in the background doing all kinds of things to help you and society...such as...



Weather Radars

(severe weather monitoring and alerts, airborne navigation, crops)

Air Traffic Control

(Long-range, short range, airport surface movement)

Space Radars

(remote sensing, water vapor, water temp, wave heights and others)

Marine Radars

(navigation, pollution spill and tracking, search and rescue, wave height)

Defense

(UAS detection, protect the nation and its interests from harm and others)

New Applications

(DSRC, vehicle control and avoidance. Others)



RSEC (radars come in all sizes)





So although you may not have directly used a radar in the past few days, but to get here to take this class consider this...you flew in a plane, maybe rode in a ship, perhaps checked the weather to see what clothes to bring to DC, ate some food, etc.. Radars were involved in all of those activities. So they still affected your life and travel

The various types of radar systems running in the background made sure you could do all of these things safely and efficiently...you did not have to think about it. That's good.



How does a radar work and how does that relate to what you're here to learn from this class?

Radars send beams of energy out to a target that get reflected back to the receiver, it process that returned signal and provides information to the user...range, bearing, speed, altitude or other types of data. A computer reads the data and presents some sort of graph or figure, like a TV screen with blips on it or perhaps weather phoneme as shown in the previous pictures



RSEC and Spectrum

For successful operation and use, the radar needs access to RF spectrum, transmit power, and a particular frequency or assignment to operate on. All of this depends on what the radar is trying to accomplish and what kind of data it provides to the user.

Like any other system that transmits RF energy, rules have to be set up so that the radar system uses its' spectrum efficiently, and does not cause interference to other systems.

NTIA is the federal agency that regulates how radars use spectrum allocated to government radar service.



Radar Spectrum Engineering Criteria (RSEC)

NTIA manages the federal agencies and how that relates to spectrum usage by radars via the RSEC. Its been in place since the early 1970's. The RSEC has been modified over the years as technology has changed and more emphasis has been placed on spectrum efficiency and sharing, since the advent of Broadband systems. NTIA is always reviewing the standard to see if it can be made better and increase spectrum efficiency.

Similar to ITU-R SM 1541-6 Annex 8



PURPOSE OF RSEC Chapter 5.5 of NTIA Redbook

- Ensures an acceptable degree of electromagnetic compatibility among radar systems, and between such systems and those of other radio services sharing the frequency spectrum.
- Promotes efficient use of the spectrum.
- Sets standards for radar transmitters, receivers, and antennas.



RSEC Criteria

Summary Table From Redbook Section 5.5.2

Radar Description	Applicable Criteria
Group A Non-pulsed radars of 40 watts or less rated average power; or Pulsed radars of 1 kW or less rated peak power; or Radars with an operating frequency above 40 GHz; or Man-portable radars; or Man-transportable radars; or as described above; or Expendable, non-recoverable radars on missiles	Criteria A See 5.5.7.1
Group B Radars having a rated peak power of more than 1 kW but not more than 100 kW and operating between 2900 MHz and 40 GHz	Criteria B See 5.5.7.2
Group C	Criteria C
All radars not included in Group A, B, D, or E	See 5.5.7.3
Group D	Criteria D
All fixed radars in the 2700-2900 MHz band	See 5.5.7.4
Group E	Criteria E
Wind Profiler Radar (WPR) operating on 449 MHz	See 5.5.7.5





Each RSEC category has unique standards and requirements that have been developed over many years. NTIA's System Review Branch uses RSEC to certify radar systems meet federal standards. An automated tool called El-Cid compares system input data submitted by the agencies to the required standard of that field. It does checks and reports back on the fields if they pass or fail a particular part of the standard. SRB works with the agencies to resolve the problems, if any arise. SRB consults with SEAD at times to resolve or interpret the RSEC when the automated program cant quite analyze it.

What does it actually do?

The RSEC, via El-Cid, uses measured or calculated frequency domain data, along with the waveform's time (pulse width and pulse rate), modulation (chirped, phase, none, or combination) and power characteristics (peak power), to regulate how much energy or signal is permitted in some bandwidth on-tune, and how much energy or signal is allowed into adjacent frequencies or bands (OOB). Includes limits and emission masks for fix-tuned, tunable, and frequency hopping radar systems.

Specific items are shown in the following list;



RADAR CHARACTERISTICS ADDRESSED IN THE RSEC

- Emission bandwidth (-40 dB) for pulsed, CW, FM/CW, FM pulsed, phase coded systems and hopping radars
- Radiated emissions (roll-off and spurious limits, relative to peak power)
- Radar Tunability
- Antenna patterns and sidelobe levels
- Frequency tolerance
- Receiver IF selectivity 3 dB bandwidth
- Receiver RF selectivity 3 dB bandwidth (under study)
- Image and spurious rejection
- Local-oscillator radiation





Time (microseconds)



Same radar pulse in frequency domain



Frequency (MHz)



RSEC Mask and various parts



Frequency Relative to Fundamental (MHz)



How is the RSEC Managed?

- NTIA has developed software programs that provides current and optional emission masks for the RSEC and ITU-R limits.
- Through measurements, emission characteristic of radars with various types of output devices, signal processing, filters and antennas are determined. Important as radar technology advances to keep updating the measurement system.
- Apply software program (emission masks) to measured and calculated emission characteristics to assess compliance of radar systems to emission mask.
- NTIA engage the radar manufacturers and radar output device manufacturers to identify state-of-the-art capabilities.
- Through the IRAC/TSC, in coordination with Federal agencies, reach agreement regarding RSEC changes for future radar systems. This coordination is always in progress.



Examples of RSEC emission masks



Note how the shape of the mask changes according to the criteria For the roll-off, bandwidth, and suppression level...for one set of waveform characteristics.



AIRPORT SURVEILLANCE RADAR Klystron Output device

(radiated measurement in far field of antenna)



RSEC Criteria D Radar and Emission mask



RADIONAVIGATION RADAR (Coaxial Magnetron WO Filter)



Criteria C Radar



RSEC/FHOP

Compliance Tools by OSM NTIA \times Report File **RSEC Analysis Plot** Note: Enter Measured Data to do a complete analysis Mod Type=Pulse No Mod/FHop FC=1300 FCM=1300 Bc= Bs=185.93 t=2 tr=0.05 d= PRR=150 Pp=76.53 N=1 Pt=14.3115 bw40dB=208.8199 bwRSECn=205.5361 bwRSECo=205.5361 PG=0 XdB=60 RSECcrit=C 0 Measured BWres: 000.0 Criteria AN-TPS-59 DETtype: -10 с 🗸 RSEC Mask C 20dB/dec Theory FY2020 RSEC C 30dB/dec -20 BW@40dB Custom MK 205.536 -30 (qB) Compliance Tools by OSM NTIA × _ Overage -40 File Execute View Help Power (Legacy NTIA RSEC Compliance Program (RCP) -50 Radar Modulation Info: Relative Radar Info Radar Settings: Mask FC -60 User Defined V AN/TPS-59 FL 0 PWR 76.53 Pulse (unmodulated w/F Modulation Settings Operational FH 0 GT 0 Stage . Res BW -70 FC 1307 RBW 0 SPS#: Number Her Date: 01-Aug-20 Fixed . Normalize -80 Trace Control Criteria: C BW40dB: 205.5361 RSEC MASK Slope: 20 XdB: 60 RSEC Old RSEC Mask C 20dB/dec -90 Legend -20 (gp) RSEC New Measured Data: TSP59 --40 101 -100 Theory Title -60 1300 1200 900 1000 1100 1400 1500 1600 Measured Frequency (MHz) -80 900 100 Z -120 Overage Underage -140900 1000 1100 1200 1300 1400 1500 1600 1700 The appropriate RSEC Mask will be selected ... Frequency (MHz) YLim (dBm) Span (MHz) -140 802 TSP59 000.00



Radar RSEC Measurements

Radar measurements are not easy to do correctly and its easy to make mistakes. People make mistakes which leads to problems and possibly failing the RSEC standards. It takes years of experience and specialized test equipment and software to get the dynamic range and bandwidth to obtain measured data, that can be plotted against a RSEC mask. ITS based in Boulder, Colorado does them for NTIA, federal agencies, and manufacturers. Frank Sanders has been doing it for close to 30 years.



You can download a report that tells you how to do radar emission measurements from the ITS website. Look on their site to see other reports on radars for interference cases and measurements as well. Mr. Sanders will be here at USTTI if you have questions for him about doing radar measurements for your own administration or having ITS help in setting up your own radar emission measurement programs.

http://www.its.bldrdoc.gov/publications/05-420.aspx

ITU-R M1177-2 is very similar, developed with other countries for ITU-R SM 1541-8.



RSEC and International forums

ITU-R Working Party 5B (Radiodetermination) is the body within the ITU-R that addresses issues concerning radars and coordinates with other Working Parties when the same band is used by different radio services and EMC analyses is required for WRC proposals. The RSEC is fairly close to ITU-R SM1541-8 with its application of rules to regulate radars. Many other countries use it in lieu of making their own version of the RSEC. Working party 1C is the Group that controls that recommendation.

The need for better spectrum efficiency is pushing the RSEC and ITU-R SM1541-8 to place tighter limits on how much spectrum radars use and how they affect other radio services. There is a big push for radar bands to be shared with LTE Broadband and/or unlicensed services, so regulators are needing standards to help in that planning analyses. Tighter emission standards leads to more sharing.





RSEC Changes and Developments

- NTIA has developed Matlab based computer applications that provide current and optional emission masks for the RSEC and ITU-R limits.
- Identify, through measurements, emission characteristic of radars with various types of output devices, filters and antennas.
- Apply software program (emission masks) to measured emission characteristics to assess feasibility of establishing a more spectrum efficient emission mask.
- Engage the radar manufacturers and radar output device manufacturers to identify stateof-the-art capabilities.
- Through the IRAC/TSC, in coordination with Federal agencies, reach agreement regarding draft revised emission masks for future radar systems. This coordination is in progress.
- Criteria A was developed over a few years period to accommodate lower power radar systems.
- Also added a Category for Commercial off the Shelf (COTS) equipment.
- Receiver IF bandwidth standard based on 3 dB emission bandwidth is the latest RSEC standard that was added.
- Receiver RF bandwidth standard based being studies and added in 2023.



The RSEC is reviewed in the Interdepartmental Radio Advisory Council (IRAC) Technical Subcommittee Working Group 1 with the appropriate DoD representatives and other agencies as well. Through the TSC, NTIA encourages Radar Systems Program Offices and manufacturers to give presentations on radar technology and developments. This information is very helpful to NTIA as the RSEC is revised. NTIA works with radar manufactures if they have any questions or find any problems with the RSEC as they design systems.





- Radars are important to a functioning society, even if they are not much fun as smart phones or broadband.
- Radars need spectrum to operate.
- Radar spectrum needs to be carefully regulated.
- RSEC must change as radar technology advances.
- Efficient use of the spectrum benefits everyone.
- As more bands are shared by radars and Broadband systems, the standards must adapt to facilitate it.





Future Work

Develop RSEC masks for complex waveforms not addressed in the NTIA Redbook, that intermix modulation types.

Any questions? Feel free to Call or email me

