Receiver Specification?

What do they mean?

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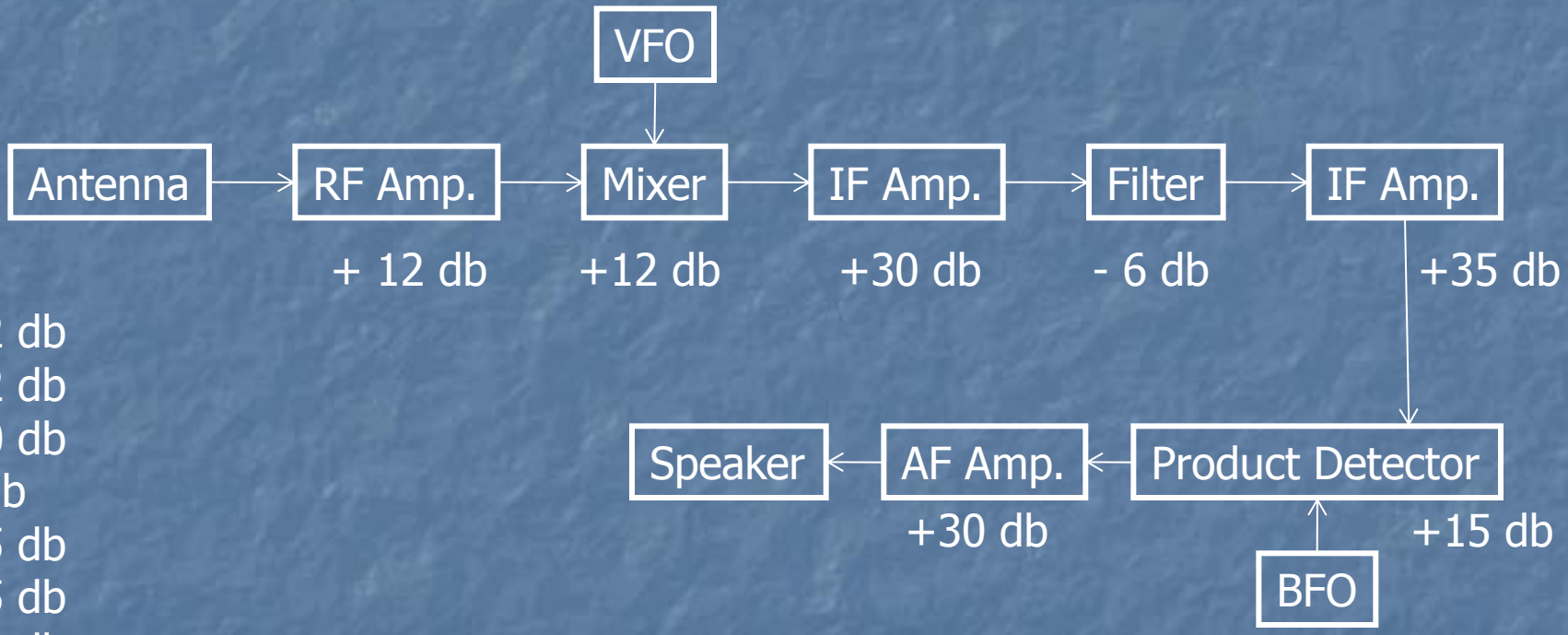
What We're Doing Today

- Stage-by-stage receiver gain – what do they mean?
- Specifications of interest – why?
- Test equipment needed
- Learn about the test method
- Actual demonstrations

Typical Receiver Block Diagram



+12 db
+12 db
+30 db
-6 db
+35 db
+15 db
+30 db
+128 db

Overall Receiver Gain

Specifications of Interest

- Noise floor/Minimum discernable signal
- Blocking dynamic range
- 3rd Order dynamic range
- 3rd Order intercept
  - @ 20 kHz
  - @ 5 kHz
  - @ 2 kHz

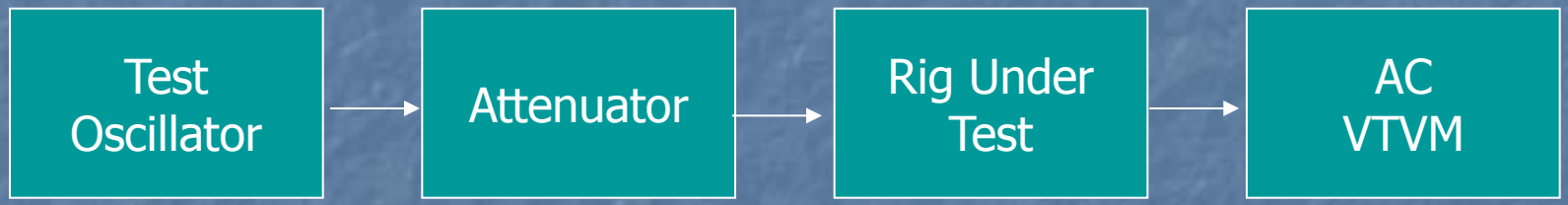
Basic Equipment Needed

- Two oscillators 20 kHz (or 5/2 kHz) apart, 20 or 40 meters, 0 to +10 dbm output, for dynamic range
- One oscillator 20 or 40 meters, -50 dbm, for MDS
- AC VTVM or Analog Voltmeter and probes
- Two attenuators, 0-80+ db each
- 50 ohm -6 db hybrid combiner
- Assorted 50 ohm connecting cables
- Audio 8 ohm load with speaker plug
- Paper, pencils, scientific calculator

Noise Floor or Minimum Discernable Signal

- When the audio is 3db above the hiss in the speaker with no signal applied
- Too low a noise floor is may not be an advantage – overload potential of 1st mixer
- The narrower the filter, the lower the MDS
- Measured in db, usually around -140db to -120 db. Example: S3 is -109db
- In today's rigs, noise floor is frequently limited by phase noise from the VFO circuitry

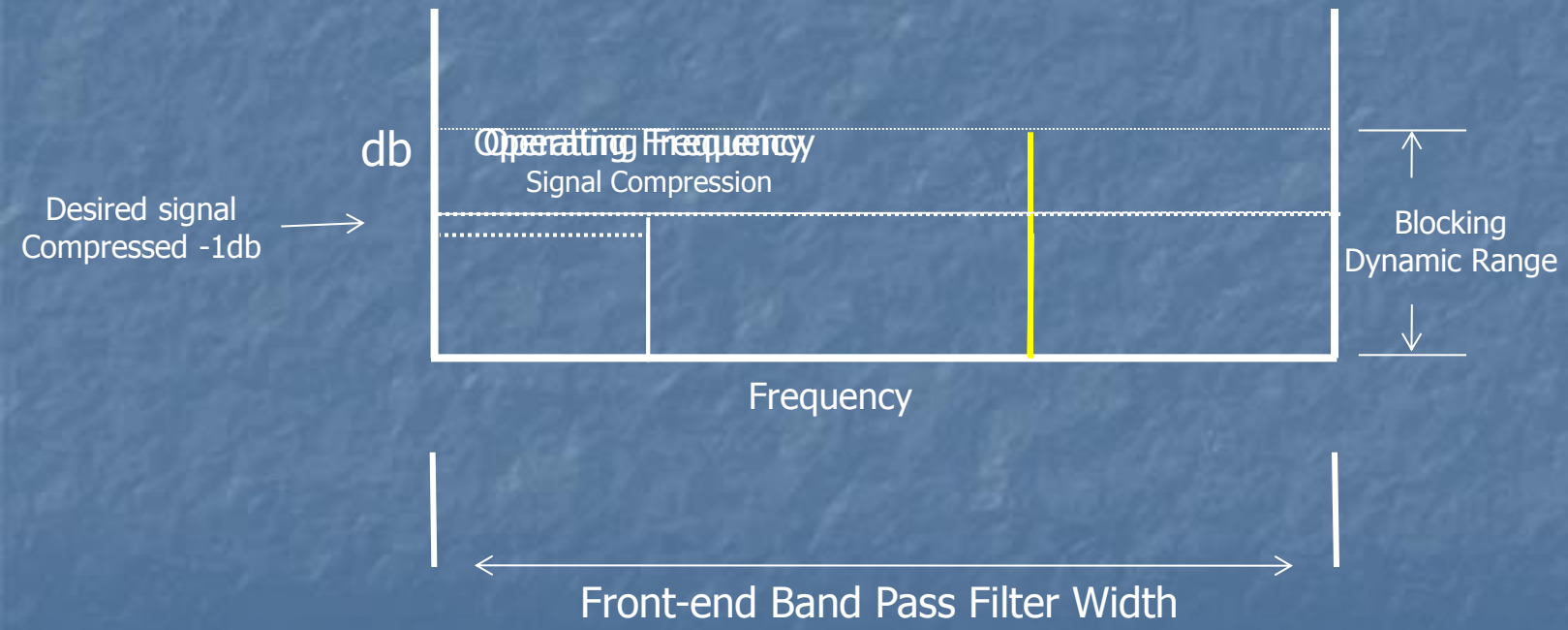
Noise Floor Measurement



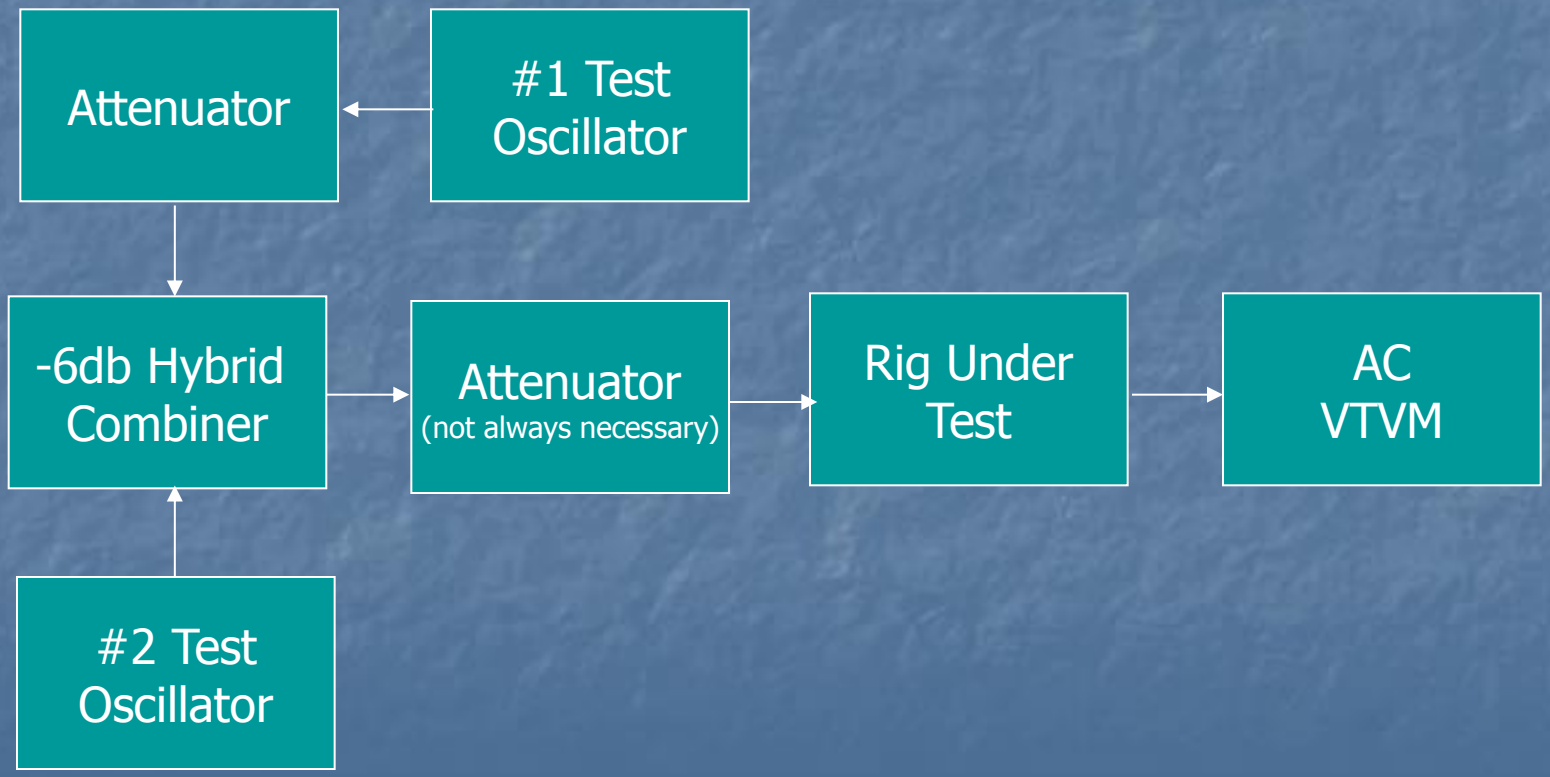
Blocking Dynamic Range

- When two signals come within the bandpass of the rig, as the off frequency signal becomes stronger, the received signal eventually becomes desensitized.
- The difference between the noise floor and the signal strength at which a nearby signal reduces the sensitivity on the received signal by -1db.
- Measured in db. The larger the better.
- A good receiver will be greater than 80db

BDR Example


db
Operating Frequency
Signal Compression
Desired signal
Compressed -1db
Blocking
Dynamic Range
Frequency
Front-end Band Pass Filter Width

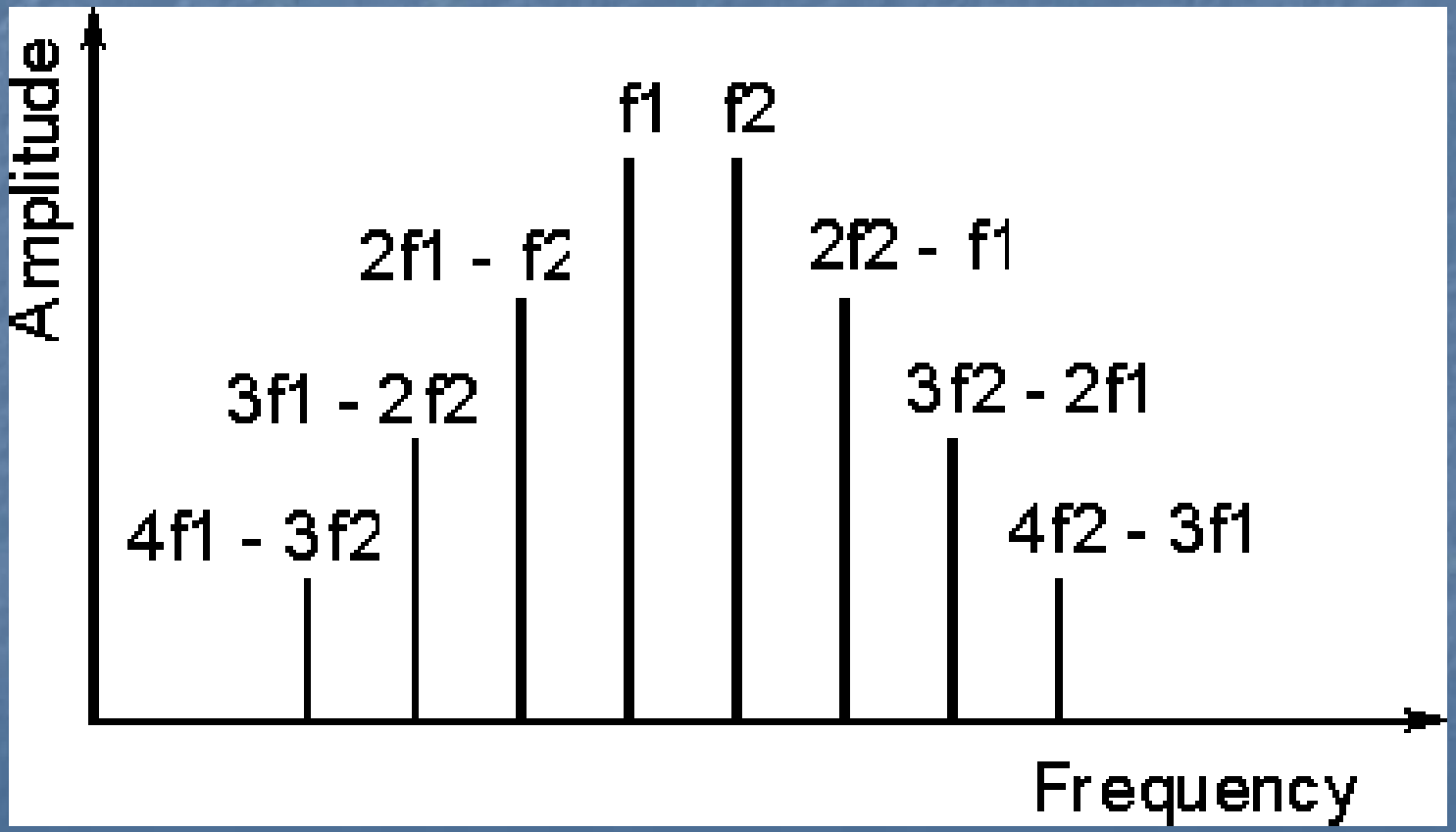
BDR Measurement



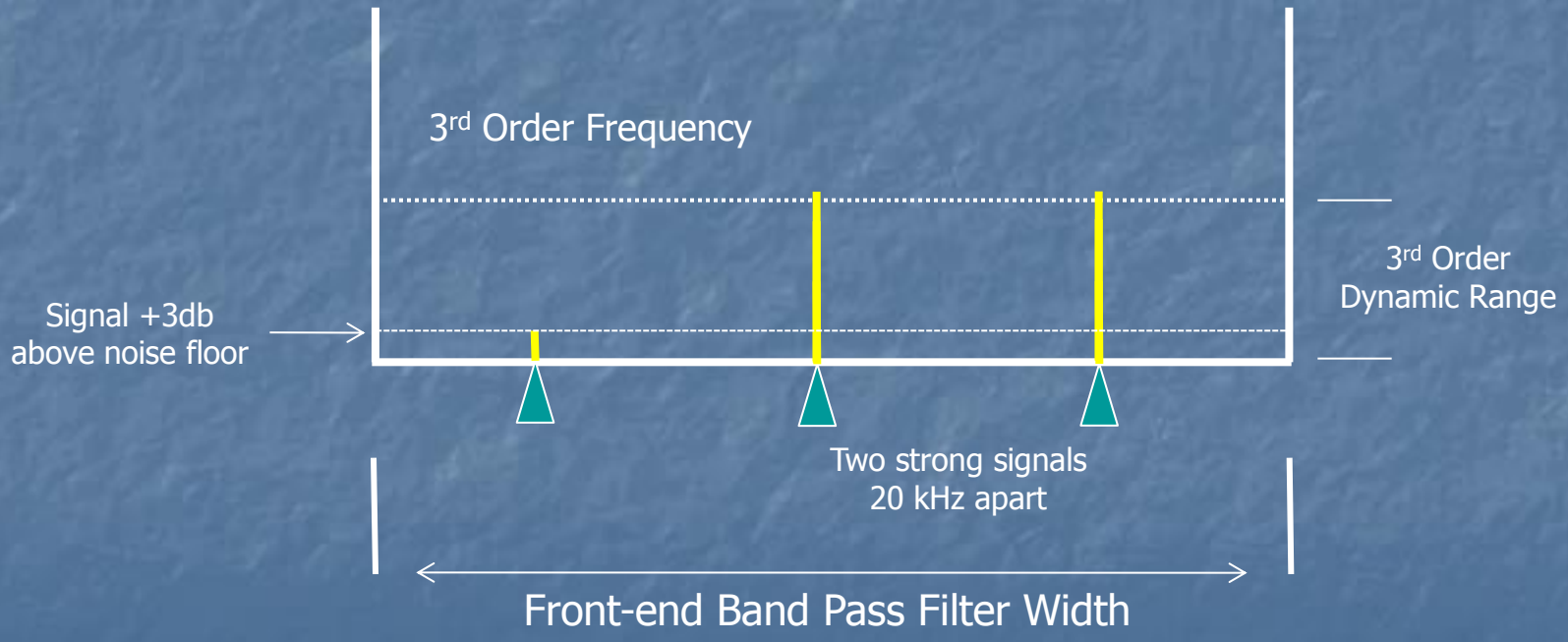
3rd Order Dynamic Range

- 3rd order IMD is similar to the BDR, only we look for the appearance of a signal on a 3rd order frequency.
- Measure when a 3rd order frequency indicates a 3db increase in noise floor
- F1 and F2 are the two signals. The 3rd order products are: 2*F1 – F2 and 2*F2-F1
  Example: incoming frequencies. 14040 kHz and 14060 kHz.
  3rd Order Products: 14020 kHz and 14080 kHz.
- 3rd Order IMD is measured in db. A good receiver will have a + db figure; higher is better.

Mixing Products



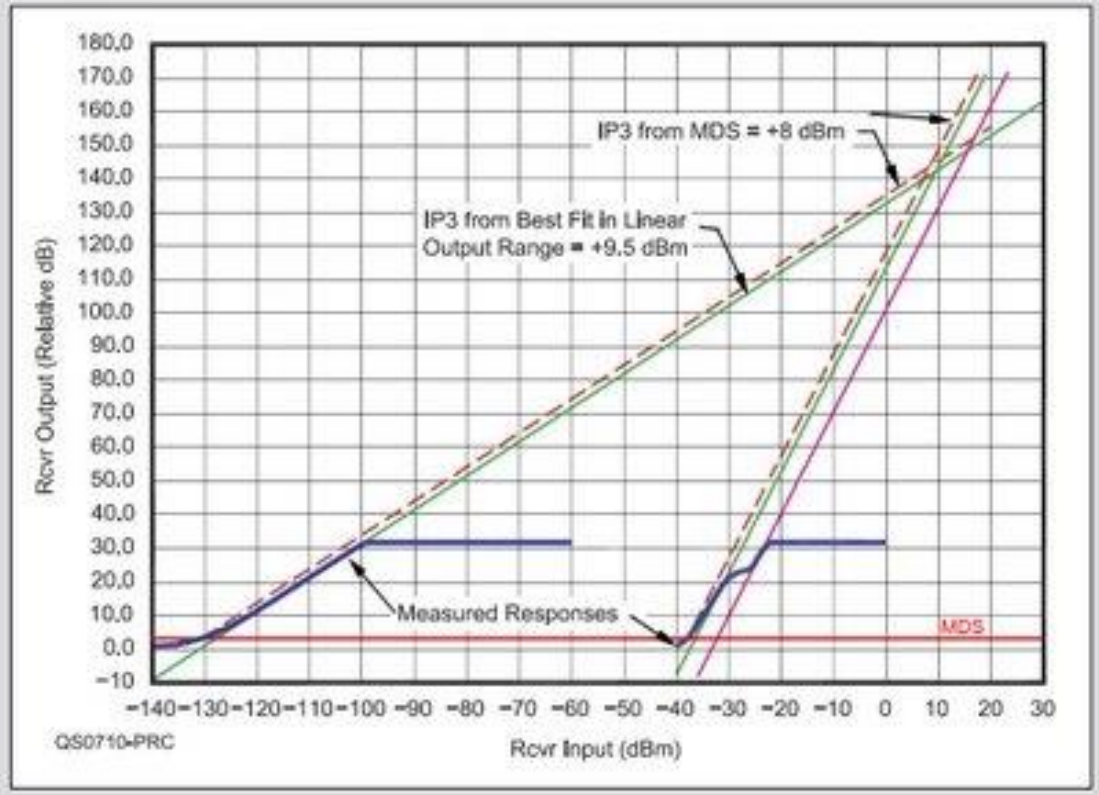
3rd Order Dynamic Range Example



3rd Order Intercept

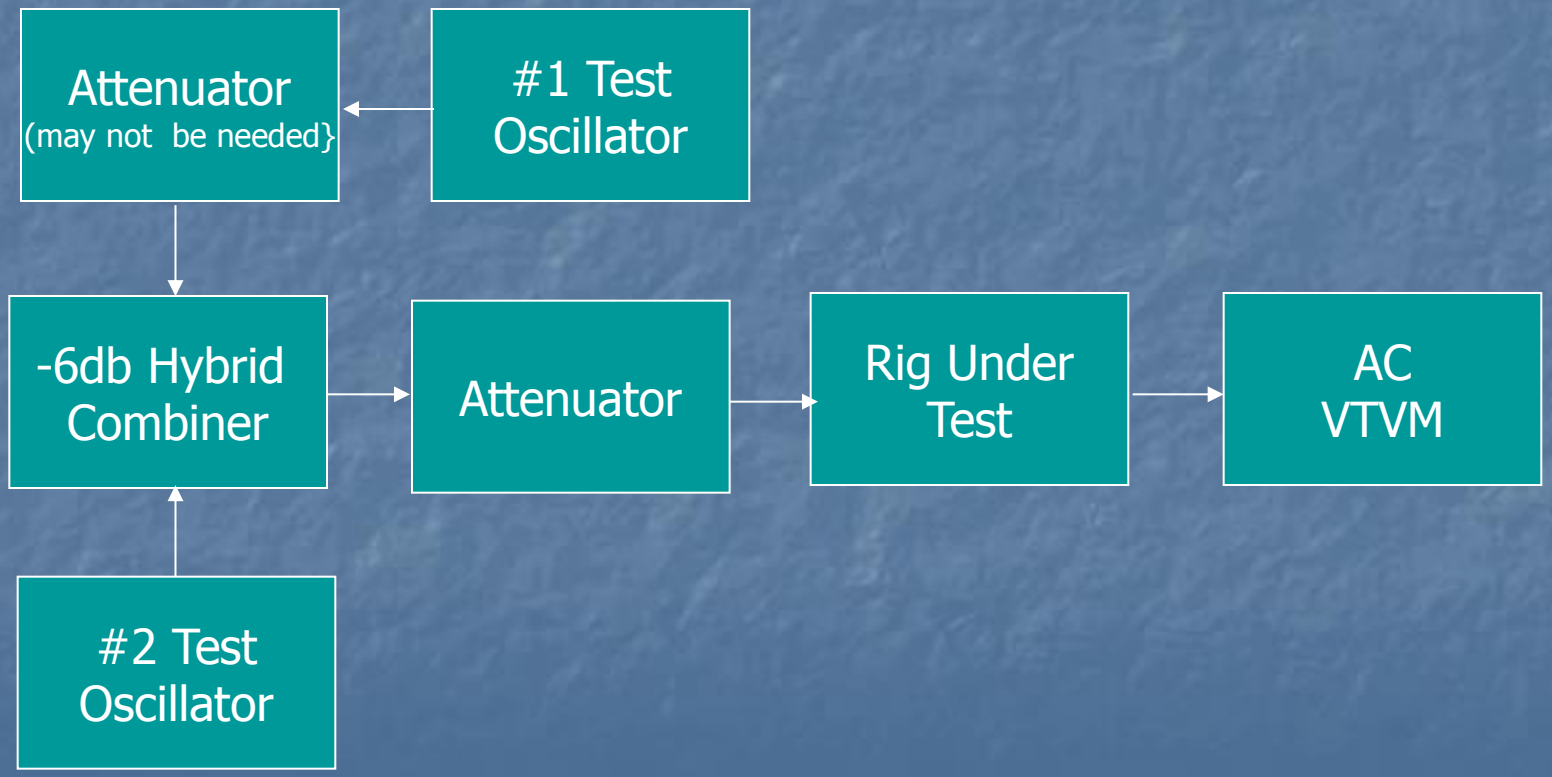
- 3rd Order IMD is measured in db. A good receiver will have a + db figure
- Calculate: (3*IMD-Noise Floor)/2
- Assume: -125db noise floor; IMD: -40db
- 3rd Order Intercept is:
  =(3*-40db – (-125db)/2
  +2.5db, an "okay" receiver by today's standards, very good 10 years ago.

3rd Order Intercept Graph



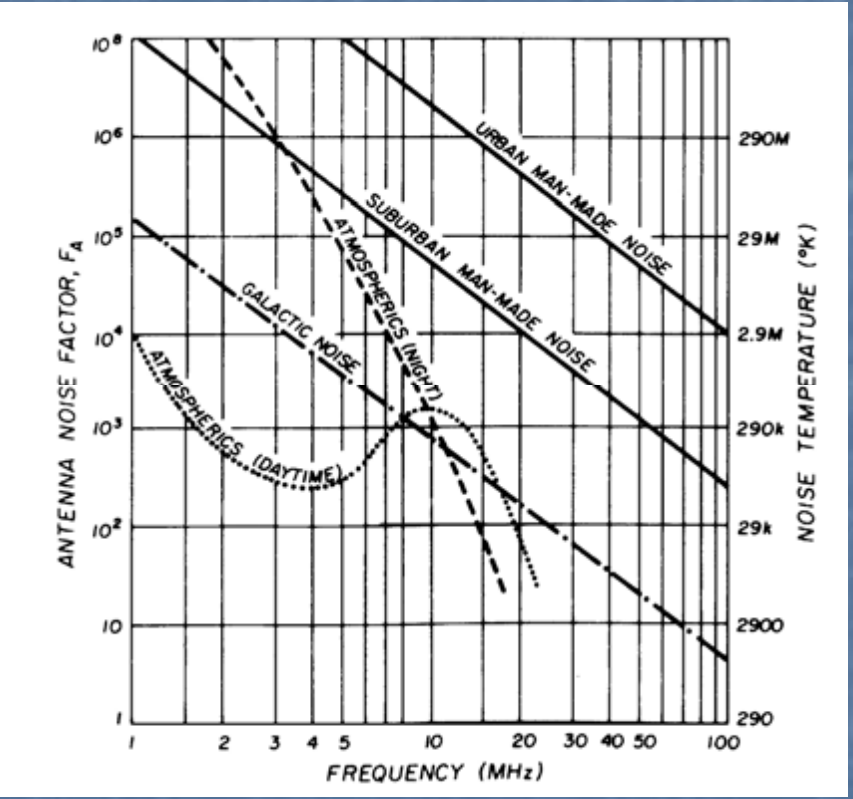
3rd Order IMD Measurement

(same as BDR)



How Good a Receiver Do I Need?

160 to 20 Meters External Noise Limits



External Noise Power

Needed Receiver Sensitivity

frequency	noise factor at antenna	noise figure	external available noise power	receiver input signal for 10 µV dB S+N/N	acceptable noise figure
1.8 MHz	15.8	12.0	- 93 dBm	15.3µV	45 dB
3.5 MHz	16.2	12.1	-101 dBm	12.6µV	37 dB
7.0 MHz	16.7	12.2	-111 dBm	4.0µV	27 dB
14.0 MHz	17.6	12.5	-113 dBm	3.1µV	24 dB
21.0 MHz	18.3	12.6	-118 dBm	1.8µV	20 dB
28.0 MHz	18.9	12.8	-123 dBm	1.0µV	15 dB
50.0 MHz	20.9	13.2	-129 dBm	0.5µV	9 dB
144.0 MHz	26.9	14.2	-139 dBm	0.2µV	2 dB

Table 1. Performance of a receiver with 0.5 µV sensitivity for 10 dB S+N/N with 100 feet (30.5m) of RG 8 A/U transmission line is shown in first two columns. Third column lists external available noise power for quiet receiving locations on each of the amateur bands. Fourth column shows receiver signal (50-ohms) required for 10 dB S+N/N on each of the bands (based on external noise). Last column lists acceptable noise figure for each of the bands (see text). Bandwidth = 2.1 kHz.

Receiver MDS: $-129db_m$

(Assume a 10 db S+N/S Ratio)

What About A Crowded Band?

What Can I Do To Improve Receiver Performance?

- Narrow the first receiver bandpass filters. This is what roofing filters do. Allows less total signal energy to reach the 1st mixer.
- Use an antenna tuner regardless of antenna SWR. Acts as a narrow bandpass filter before the signals enter the rig.
- Use an attenuator if the signals are strong. -6db of attenuation reduces the 3rd order product -18db!

Source of Receiver Specification Information
Two Primary sources

- ARRL Product Reviews and White Papers
- Sherwood Engineering, Inc. http://www.sherweng.com/table.html

Let’s make some actual measurements