Radios Used in a Contest Environment

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NCØB

Have Radios Gotten Better in the Last 5 or even 25 Years?

Why Did I Start Testing Radios ?

- K8RRH & I purchased new Drake R-4Cs in the late 70s
- Used them during the ARRL 160m CW contest
- **Radios performed miserably yet Specs Were Good**
- 70s: League expanded testing to include Noise Floor & Dynamic Range, new concepts for the amateur.
- R-4C tested well for Dynamic Range, but flunked CW contest 101
- Was the wrong thing being tested or did the test not approximate a real amateur environment, especially a CW contest environment?

- 20 kHz Dynamic Range test showed that in a multi-conversion radio it was only testing the radio's front end
- If the first IF was 6 - 20 kHz wide, be it at 5 MHz, 9 MHz or 45 - 70 MHz, the radio would overload in a pile up.
- 20 kHz test showed **no** hint of the problem
- ***Solution***: Place test signals close together so they pass through **1st IF Filter → the Next Amplifier → Mixer**
- Close-in dynamic range numbers were **ALWAYS** drastically worse than the wide-spaced numbers & correctly approximated a CW pileup

What 2 Numbers are Most Important for a Contester? ***(Especially CW Contester)***

- Noise Floor
- Close-in Dynamic Range

What is Noise Floor?

How is it Needed to Measure Dynamic Range

Sensitivity is a familiar number, normally applies to SSB.

Sensitivity = 10 dB Signal + Noise / Noise (10 dB S+N/N)

Noise Floor = 3 dB Signal + Noise / Noise (3 dB S+N/N)

Noise floor can be measured at any filter bandwidth, CW or SSB, for example

League normally only publishes noise floor for a CW bandwidth, typically 500 Hz CW filter

What is Dynamic Range?

What is the Close-in Dynamic Range vs Wide-Spaced Dynamic Range published in QST?

(Note: recent expanded League receiver tests include close-in Dynamic Range, somewhat buried in a graph)

Why is Close-in Dynamic so important?

Dynamic Range Data

Model:	20 kHz Dynamic Range	2 kHz Dynamic Range
TT-Orion 1 kHz Roofing	96	92
TT-Orion 1 kHz @ 1 kHz		85
Drake R-4C 600 Hz Roofing	85	83
IC-7800#	102	80Φ
Elecraft K2#	98	80Φ
TT-Orion 20 kHz Roofing	96	79
R-390A	81	79
TT-Omni 5	89	76
IC-775	103	76
T-T Orion 500 Hz Roofing	96	75
TT-Omni VI+	97	75
IC-781	96	75
TT-Omni B	87	74
IC-765	95	73
TS-930S	86	73
TT-Orion 500 Hz @ 1 kHz		72
Collins 75S-3C	85	72
IC-756Pro	93	71
IC-756ProII	96	70
IC-746	99	70
IC-746Pro	97	70

Model:	20 kHz Dynamic Range	2 kHz Dynamic Range
FT-1000 Mk V	98	70
IC-761	87	70
FT-1000D	94	69
FT-1000 MP	91	69
FT-1000 V Field#	90	69
TS-570D	97	68
Drake TR-4C	74	68
IC-735	83	68
FT-847	93	67
Collins KWM-380	94	64
IC-751	84	64
TS-870	97	63
FT-980	96	63
TT Argonaut V	84	59
FT-817	86	59
FT-920	98	58
FT-897	89	58
Drake R-4C (stock)	85	58
TS-2000	93	57
IC-756	93	52

Table Updated 3 October 2004
Φ Phase Noise Limited

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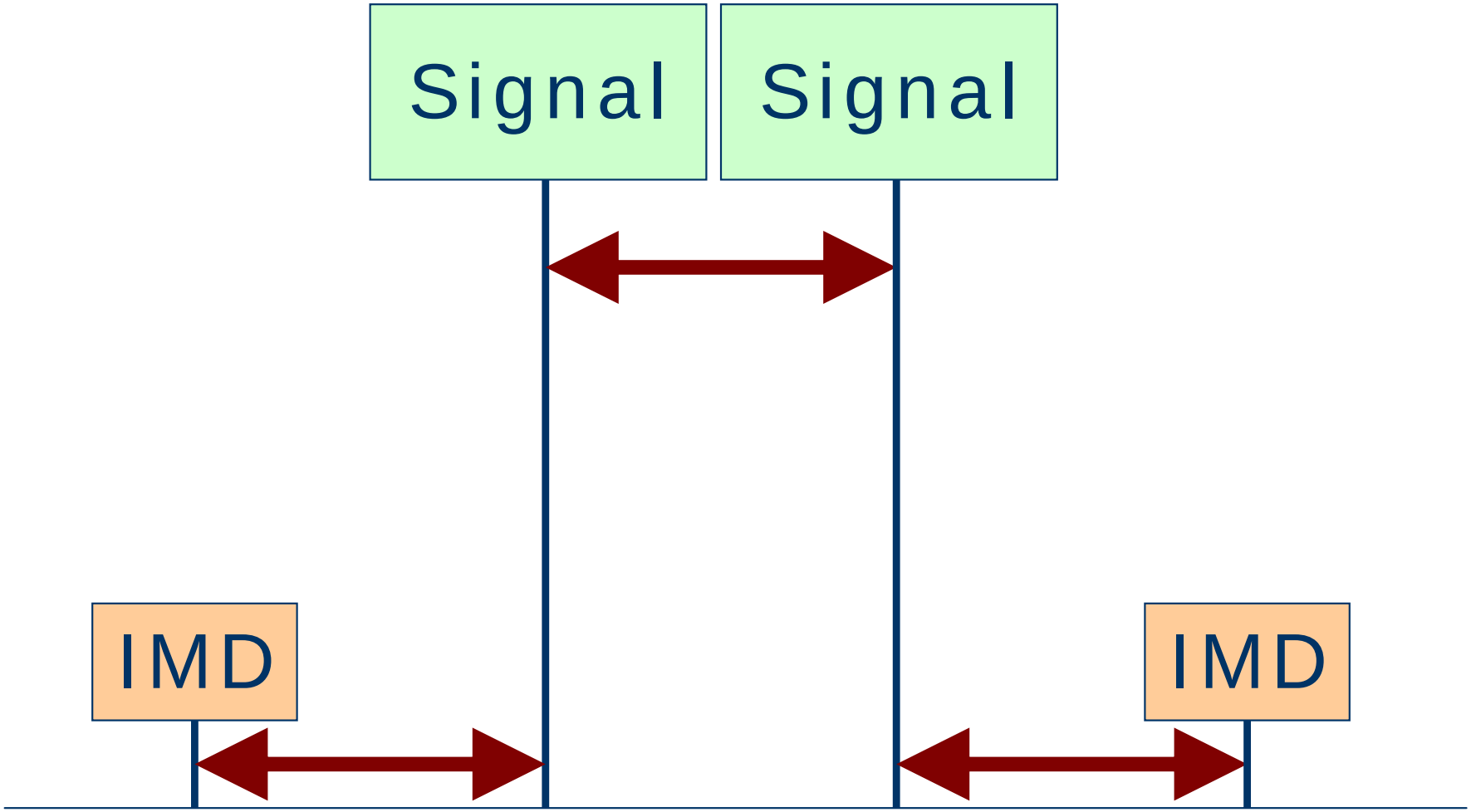
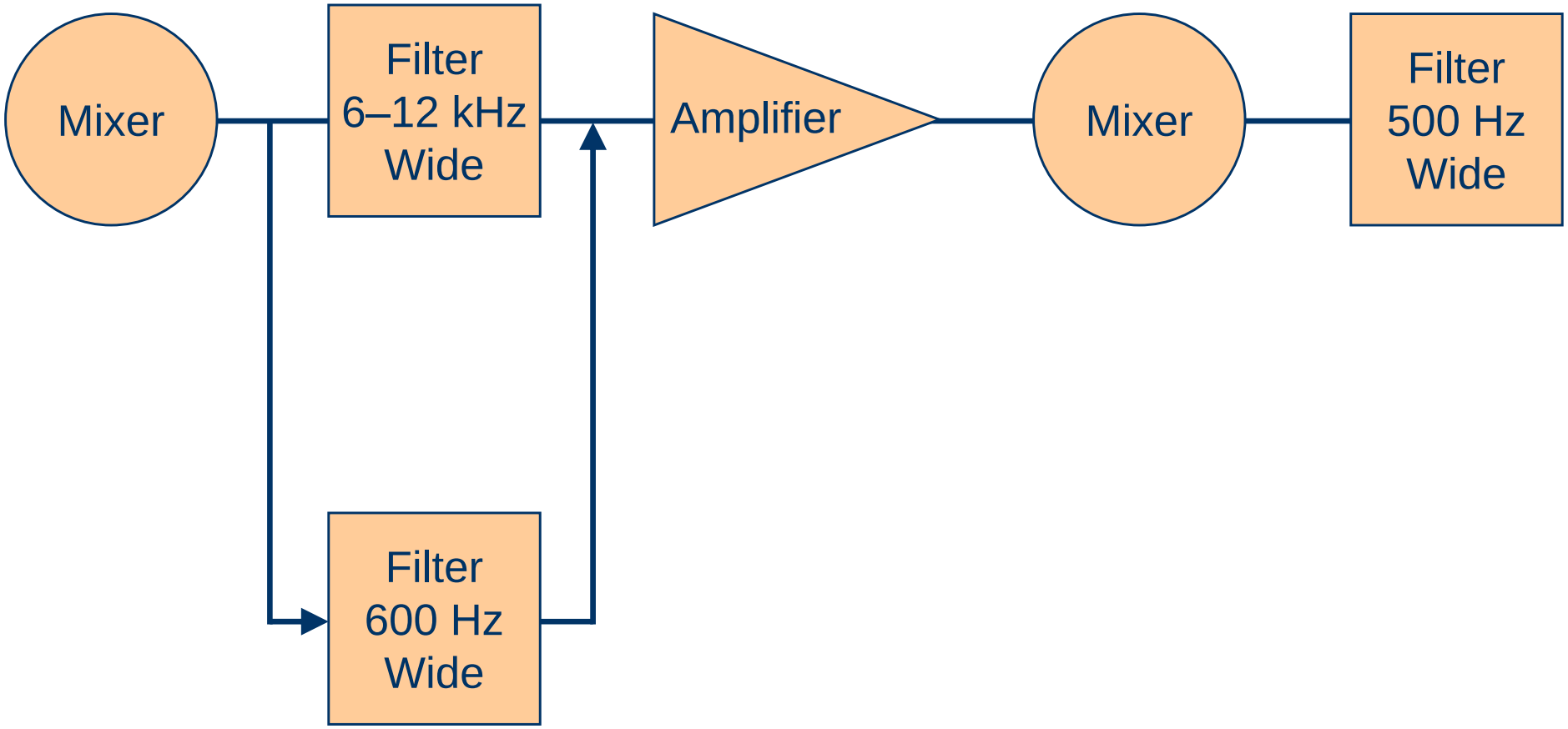
Third Order IMD



What if we could switch in a narrow Roofing Filter only slightly wider than the final selectivity?



This keeps the undesired strong signals from progressing downstream to the next stages

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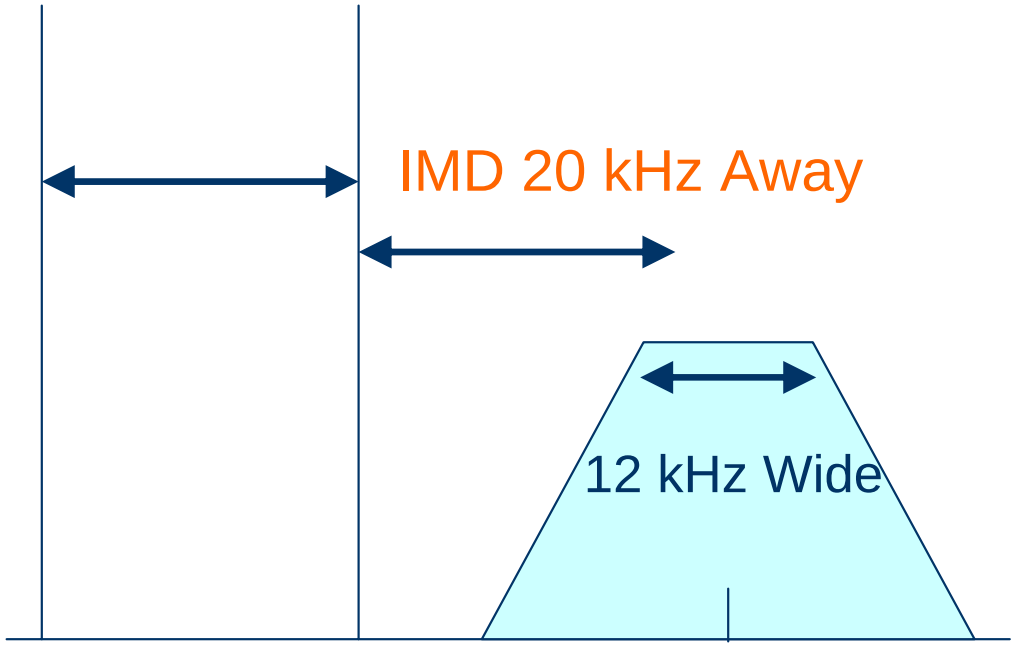
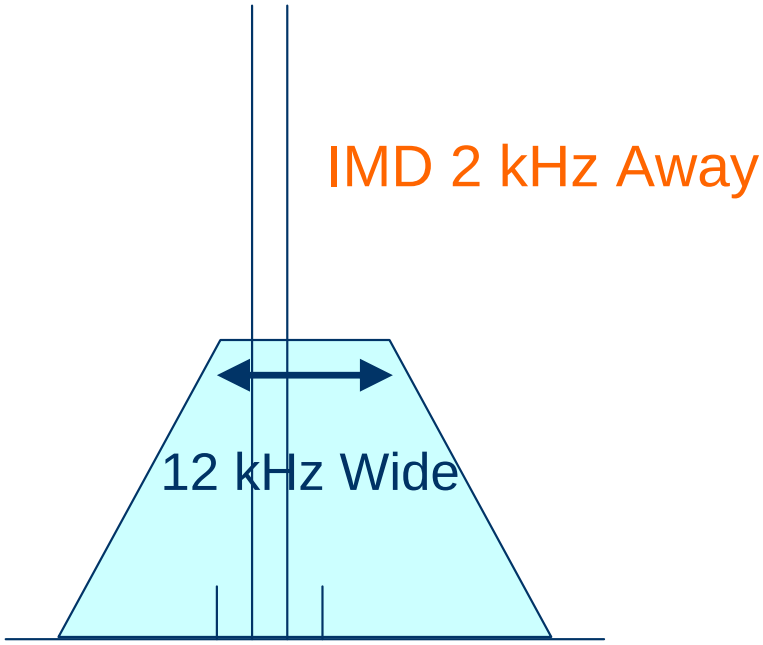
Wide & Close Dynamic Range

20 kHz Spacing



First IF Filter at 70.455 MHz

2 kHz Spacing



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Icom 756 Pro

IF BW 2400 Hz, –6 / -60 IF BW 500 Hz –6 / -60		2520 / 3540 Hz 650 / 1660 Hz
Dynamic Range 50 kHz Dynamic Range 20 kHz Dynamic Range 2 kHz		93 dB 86 dB 71 dB
Blocking above noise floor at 100 kHz spacing Phase noise (normalized) at 10 kHz spacing		132 dB 127 dBm
Noise floor: SSB bandwidth 14 MHz Noise floor: CW bandwidth 14 MHz	Off Off Pre1 Pre2	-120 dBm -127 dBm -136 dBm -139 dBm
Sensitivity at 14 MHz	Off Pre1 Pre2	0.55 µV 0.21 µV 0.14 µV
Noise floor: 2400 Hz, 14.2 MHz, Preamp Noise floor: 1000 Hz, 14.2 MHz, Preamp Noise floor: 500 Hz, 14.2 MHz, Preamp	Off Off Off	-120 dBm -123 dBm -127 dBm
Signal for S9	Off Pre1 Pre2	60 µV 16 µV 8 µV
Preamp, dB gain	Pre1 Pre2	12 dB 18 dB
AGC Threshold at 3 dB	Off Pre1 Pre2	3.5 µV 1.0 µV 0.5 µV

When are 2 Out of Pass Band Signals a Problem?

- If you know the close-in dynamic range of a radio, at what signal level will IMD start to be a problem?
- Assume S9 = 50 μV which is –73 dBm
- Assume a typical radio:
  - 500 Hz CW filter
  - Noise Floor of -128 dBm
  - Preamp OFF

Dynamic Range	Signal Level Causing IMD = Noise Floor
55 dB	S9
60 dB	S9 + 5 dB
65 dB	S9 + 10 dB
70 dB	S9 + 15 dB
75 dB	S9 + 20 dB
80 dB	S9 + 25 dB
85 dB	S9 + 30 dB
90 dB	S9 + 35 dB
95 dB	S9 + 40 dB

New in 2003 - 2004: Orion & IC-7800

- Ten-Tec Orion & Icom IC-7800
- Until the Orion came out, 99% of modern transceivers were up conversion radios. (K2 the exception)
- If the first IF is above 10 meters (30 MHz), can you switch in a narrow CW roofing filter? No
- The fractional bandwidth of a 600 Hz CW filter at 5 MHz is the same as a 6 kHz filter at 50 MHz.
- Thus most up conversion radios have a first IF at least 6 kHz wide & often as wide as 15 kHz.

New in 2003: Orion

The Orion offers the following standard roofing filters right out of the box:

- 20 kHz for FM
- 6 kHz for AM or wide Hi Fi SSB
- 2.4 kHz for most SSB operation
- 1.0 kHz for most CW operation
- One can add optional roofing filters of 1.8 kHz, 500 Hz & 250 Hz bandwidths

New in 2003 : Orion

- Roofing Filters track DSP Bandwidth Setting
- Dynamic range of the Orion with various Roofing Filters
  (Refer to Rig Table)
- Discuss Proposed Changes to Orion Design
- Bank of 7 Filters. Ignore Insertion Loss
- The Orion offers lots of features, but some quirks that some operators may find objectionable
- This discussion revolves around close-in dynamic range only & the Orion's absolutely excellent final DSP filtering down to as narrow as 150 Hz bandwidth

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New in 2004: IC-7800

The Icom IC-7800 is the other big news for the amateur community

- The often-quoted specification of a third order intercept (IP3) in excess of +40 dBm is intriguing.
- Few Published Specifications, other than IP3
- I have not tested the 7800
- All data from the League
- Wide-spaced data < Measurements from Icom Factory

New in 2004: IC-7800

Dynamic Range at 20 kHz:	98 dB
Dynamic Range at 5 kHz:	87 dB
Dynamic Range at 1 or 2 kHz:	78 dB

- Phase noise & IMD have similar magnitude at 1 & 2 kHz spacing.
- Dynamic Range > Wide-Spacing due to Tracking Preselector
- One would expect a dynamic range closer to 110 dB with an IP3 greater than +40 dBm.

What Will The Future Bring?

- **Narrow Roofing Filters** concept proved effective in late 70s with a niche after market product. It has finally been incorporated into a modern solid-state transceiver.
- **The unknown question is whether the over all experience provided by the Orion will grab enough market share to awaken the Japanese OEMs to offer this level performance.**
- Orion offers 10 - 15 dB improvement & in many cases up to 20 – 30 dB in handling close-in strong undesired signals, compared to others.

Transmitted Bandwidth Problems

- Need Improvement
- ALC induced splatter on SSB
  - Solid State Linear
- Key clicks on CW
  - ALC / Processor Affecting Rise & Fall Time

Conclusion

- Contester needs best receiver possible, especially for CW operation
- Ten-Tec Orion design is a step in a new direction. It has taken over 25 years for my concept of using roofing filters with a bandwidth similar to the final selectivity to be incorporated into an OEM rig.
- 25 years of up conversion radios have generally offered a 20 kHz dynamic range in the 90s but a 2 kHz close-in dynamic range in the 70s. Typical degradation of dynamic range within the up conversion filter bandwidth is 25 dB.

- The key question has been whether it would be possible to design an up conversion radio with the capability to maintain most of the dynamic range provided by the front end (first mixer). Preliminary numbers on the 7800 continue to show the normal degradation inside the first IF roofing filter of more than 20 dB.

- If, however, one could produce a 20 kHz dynamic range of 110 dB and a 2 kHz dynamic range of 90 dB, this would be adequate in most cases. So far this “dream” has been elusive.

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