

Performance Mods for The Popular Yaesu FT-2000

Making a Great Rig Even Better

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WØDXCC Forums – 23 July 2011

FT-2000: Strengths

- 160-6m coverage 100w
- True dual (same band) receive
- Includes VRF preselector
- Excellent ergonomics

Best overall rig value in it's price class...

FT-2000: Weakness

- Poor DR3 performance for close in signals
 - FT-2000: ~63 db
 - SSB: need 70+ db
 - CW: need 80+ db
- Early lot numbers somewhat more sensitive to damage from RF overload in SO2R and M/M environments

Quick DR3 Refresher

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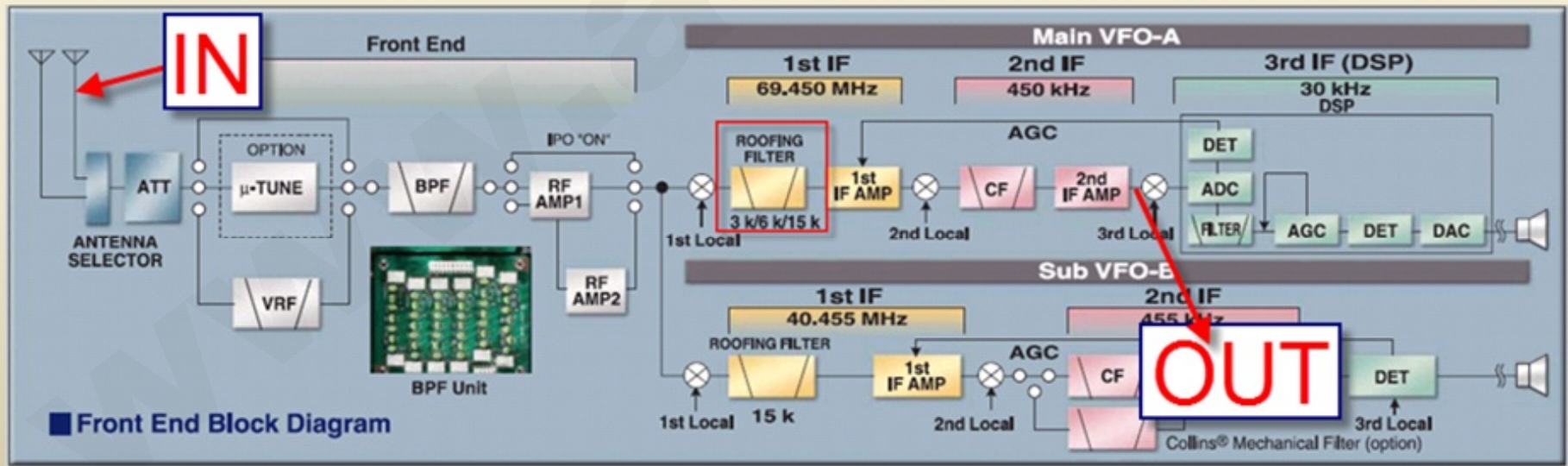


DR3

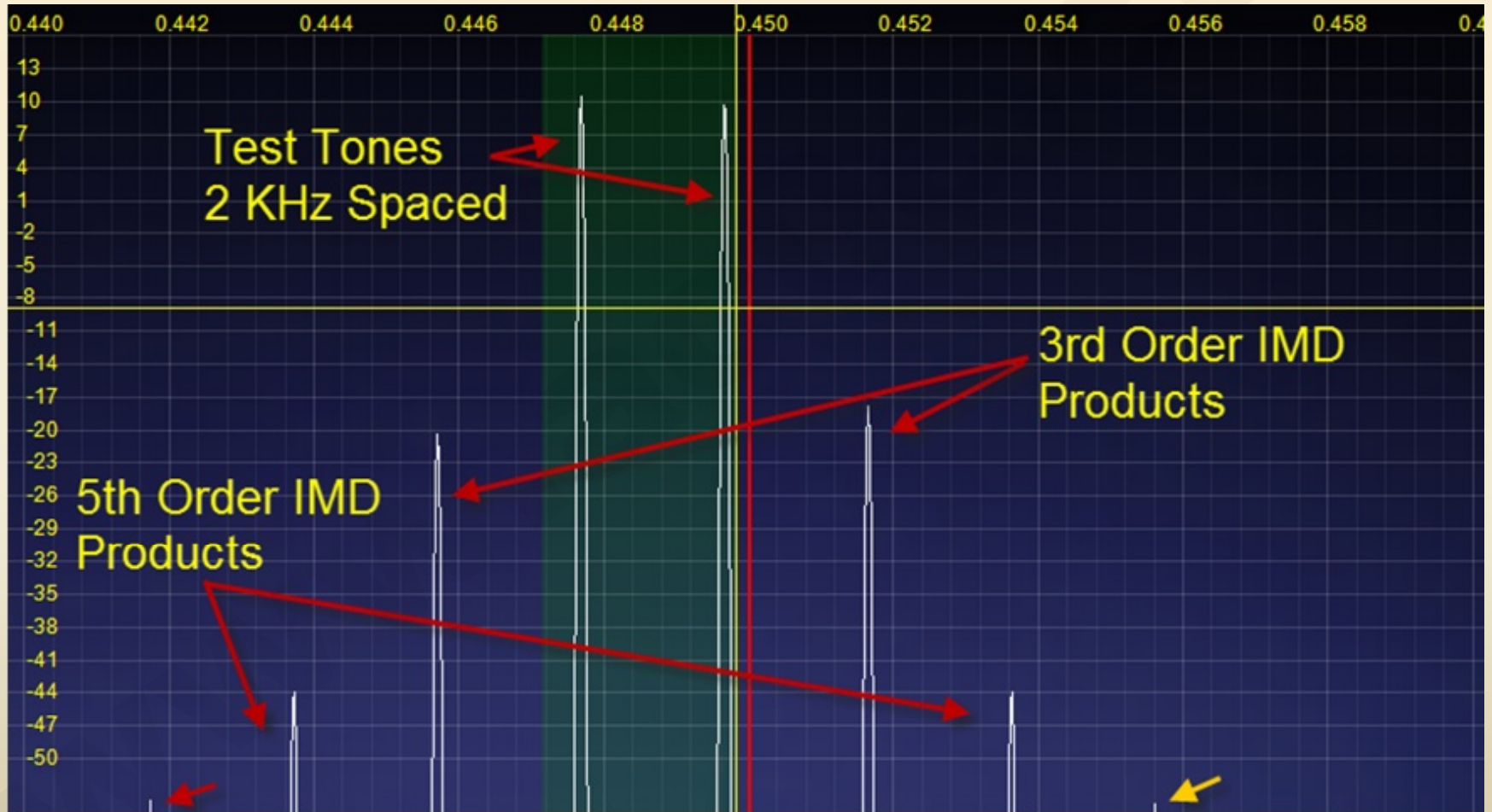
- DR3 – Third Order Intermodulation Dynamic Range
- Measures the strength of two signals that causes a IMD product at just above the noise floor
- Test signal spacing – 2/5/10/20 KHz standard - 2 KHz key
- Front end IMD levels increase by 3x signal levels (generally)
- Caused by nonlinear processes – all components can be nonlinear
- Generally – closer spacing, worse DR3 performance

IMD Products: Understanding the Plots

- Signal generator → Antenna Input
- 450 KHz Spectrum Analyser tied to output of 2nd IF
- Shows what the 3rd mixer “sees”
- Plots in presentation – actual data – NOT simulated
- IMD testing setup is very difficult – especially the signal source

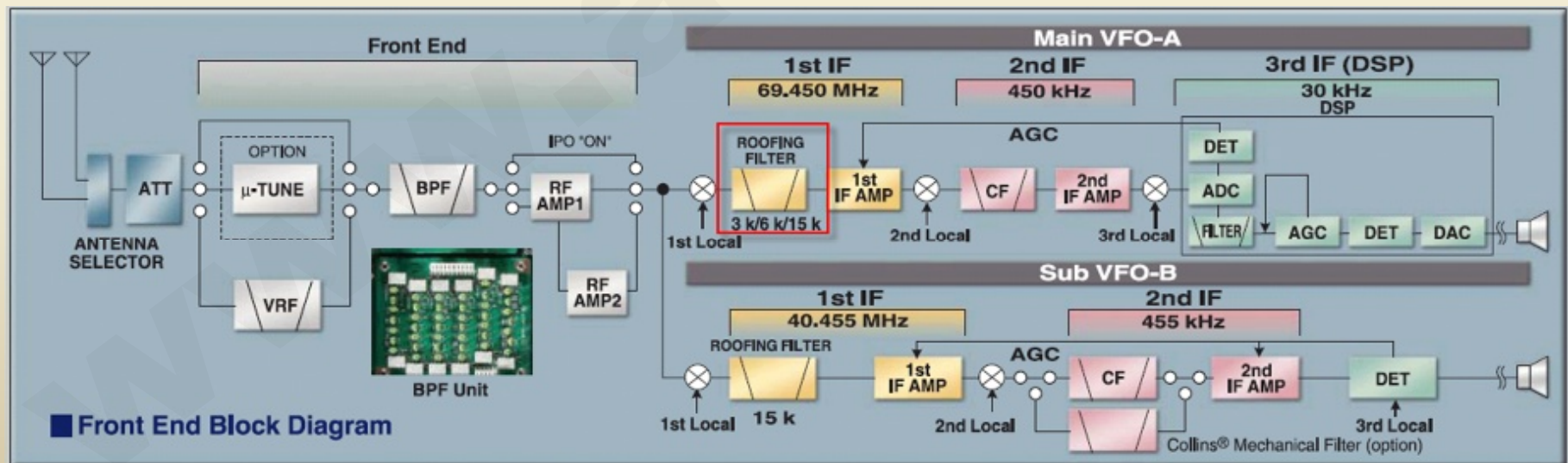


IMD Products: A Ghost in the Machine?



Roofing Filters

- Native DR3 capability of RX – called **in-band** performance
- Roof increases performance by cutting the width of the spectrum hitting the back end
- First filter following mixer
- Attenuates close-in sigs and IMD products
- Protects following stages from overload
- Complement to final stage DSP filtering



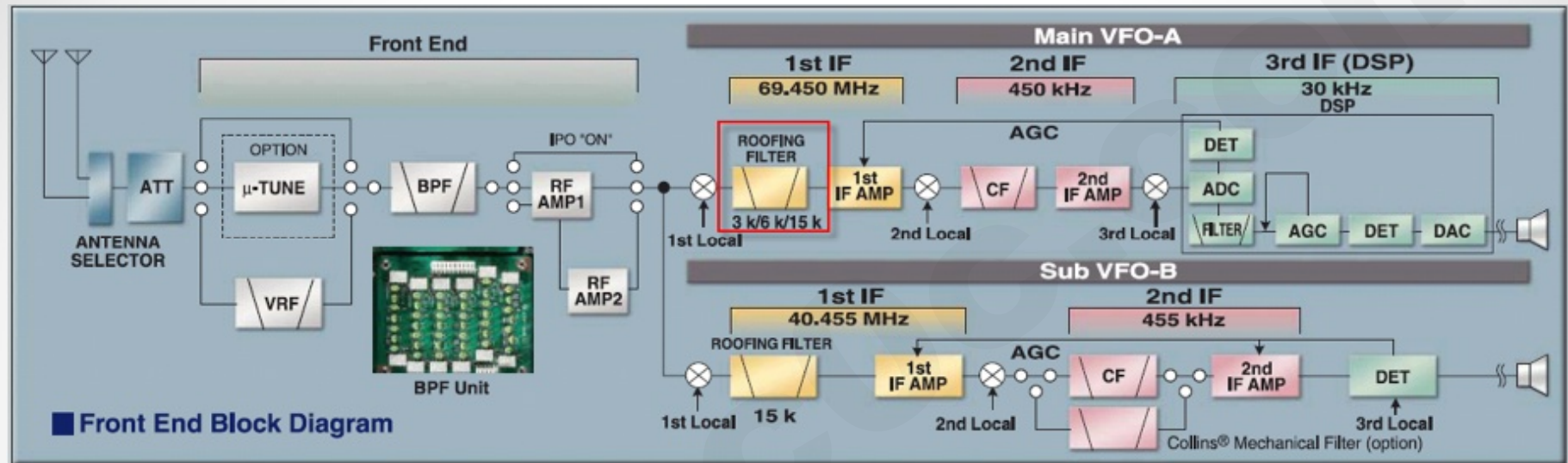
Roofing Filters

- Narrower filters → better DR3
- Improvement range tied to LO noise at extremes
- AKA “noise limited”
- Crystal price/performance “sweet spot” ~8 Mhz
- *Narrow filters sometimes are used to hide weak back-end*
- *Example of exceptional DR from antenna-speaker:
Visit PA3AKE web site*

The Mods



Mod 1 : Main RX 2.4 KHz NS Roofing Filter



- Most popular mod for the FT-2000 and FT-950
- Replace stock 3 KHz filter with NS filter
- Increases DR3 up to 20 db
- Works on all bands, and all contest/DX modes

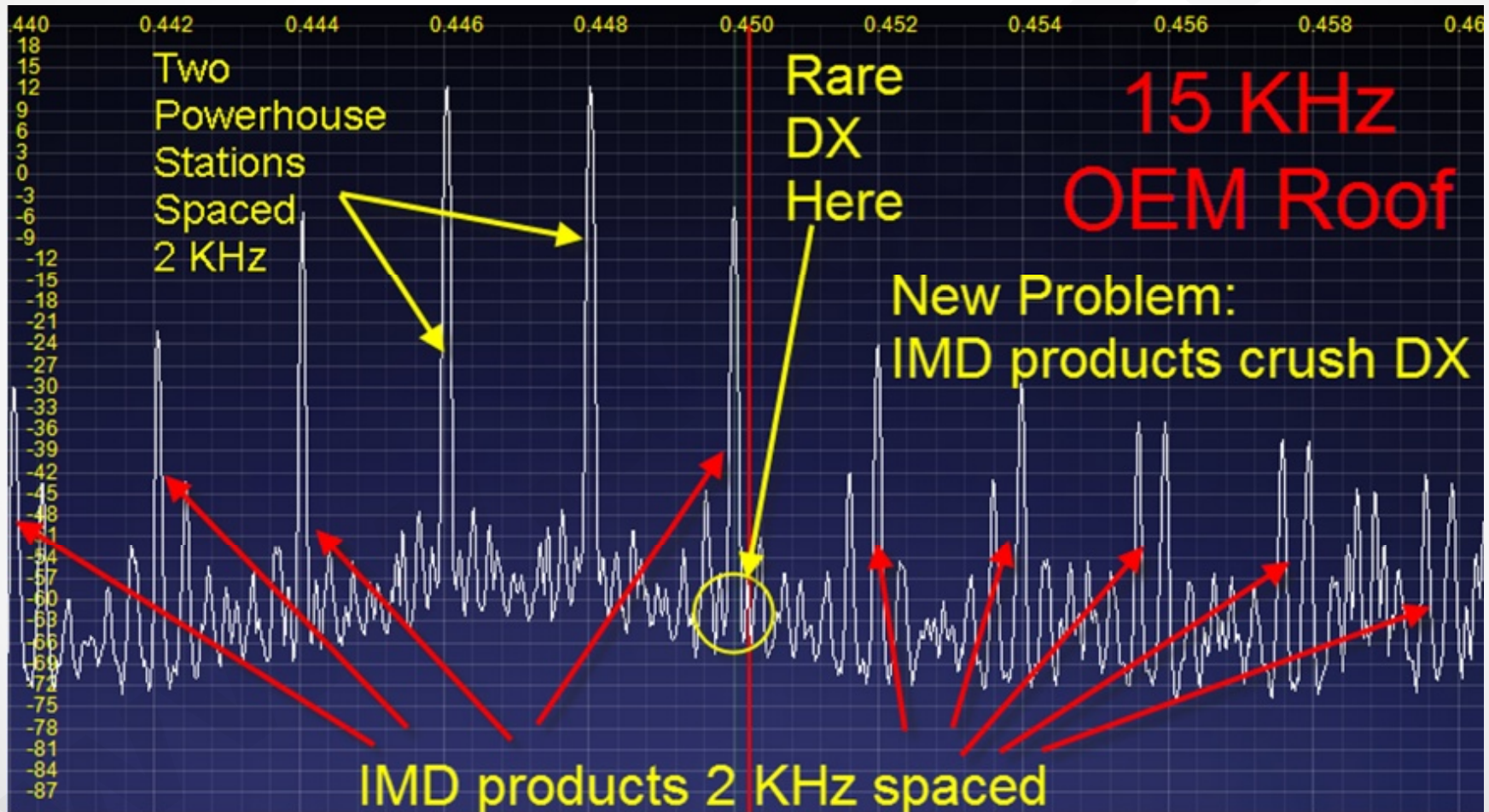
Mod 1: Main RX 2.4 KHz NS Roofing Filter

What the 3rd Mixer Sees – Lone DX station – IMD products not a factor



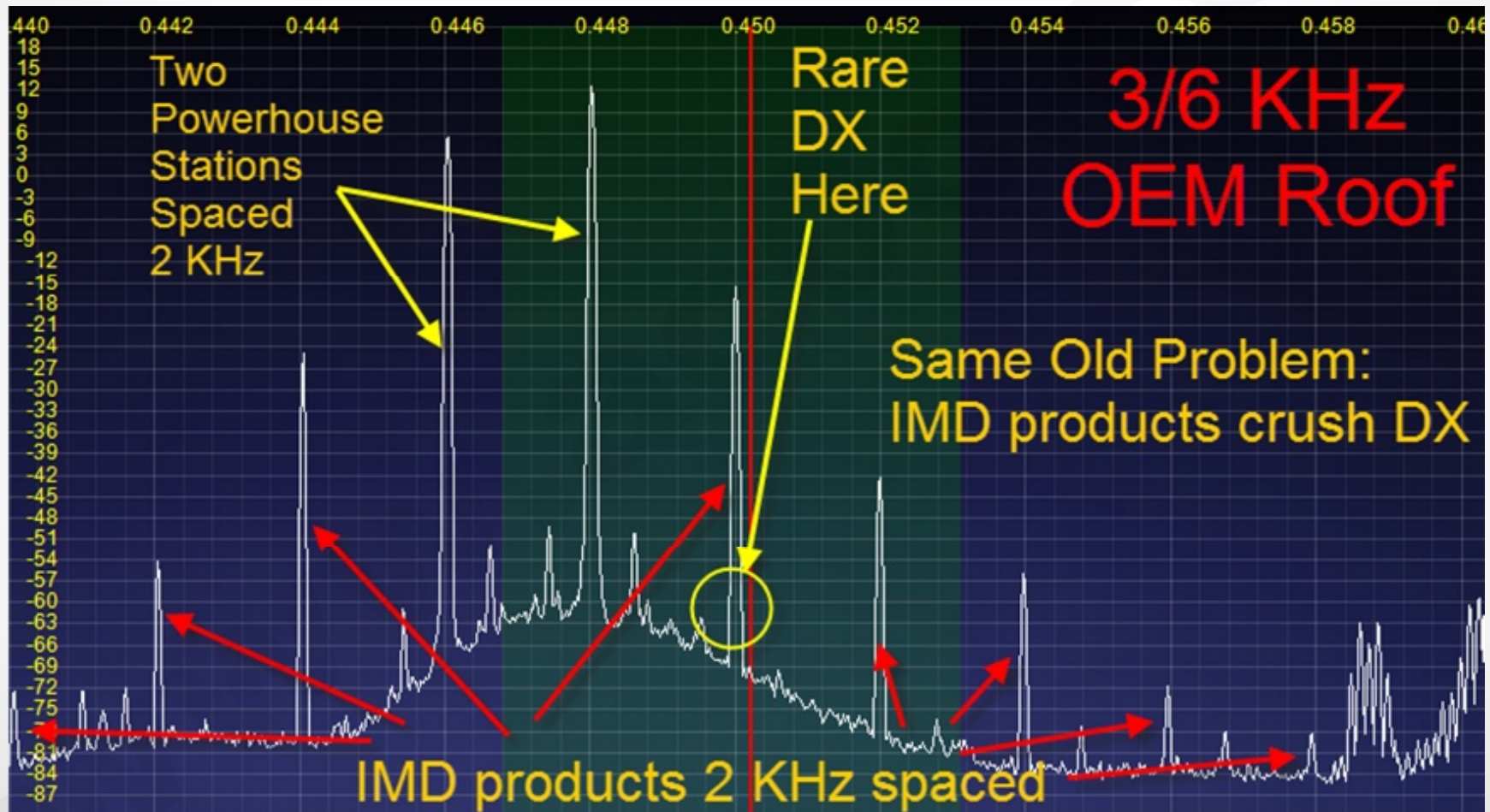
Mod 1: Main RX 2.4 KHz NS Roofing Filter

What the 3rd Mixer Sees – Two strong signals in-band – IMD everywhere



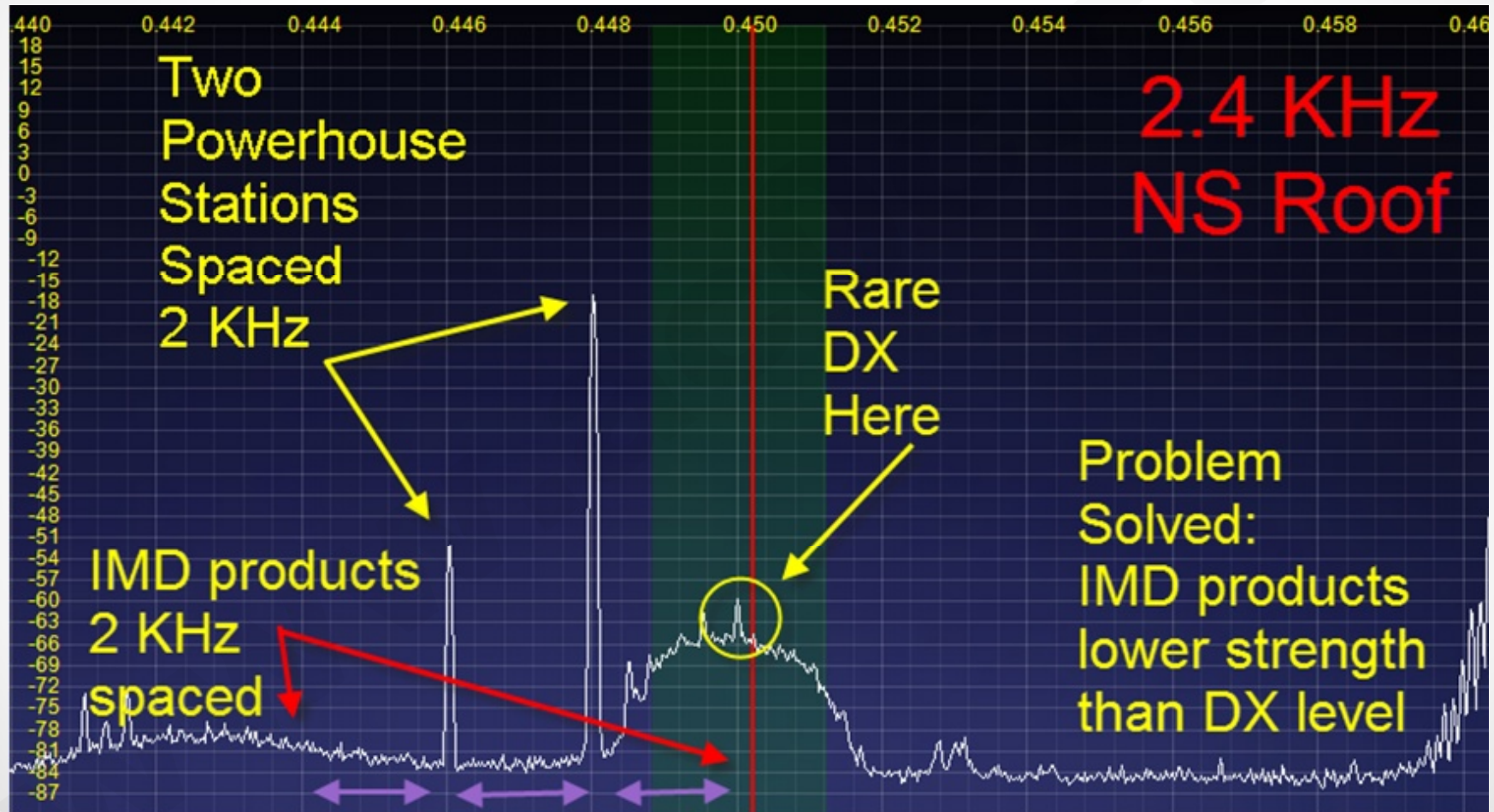
Mod 1: Main RX 2.4 KHz NS Roofing Filter

What the 3rd Mixer Sees – 6 KHz BW roof – minor reduction in signals → IMD

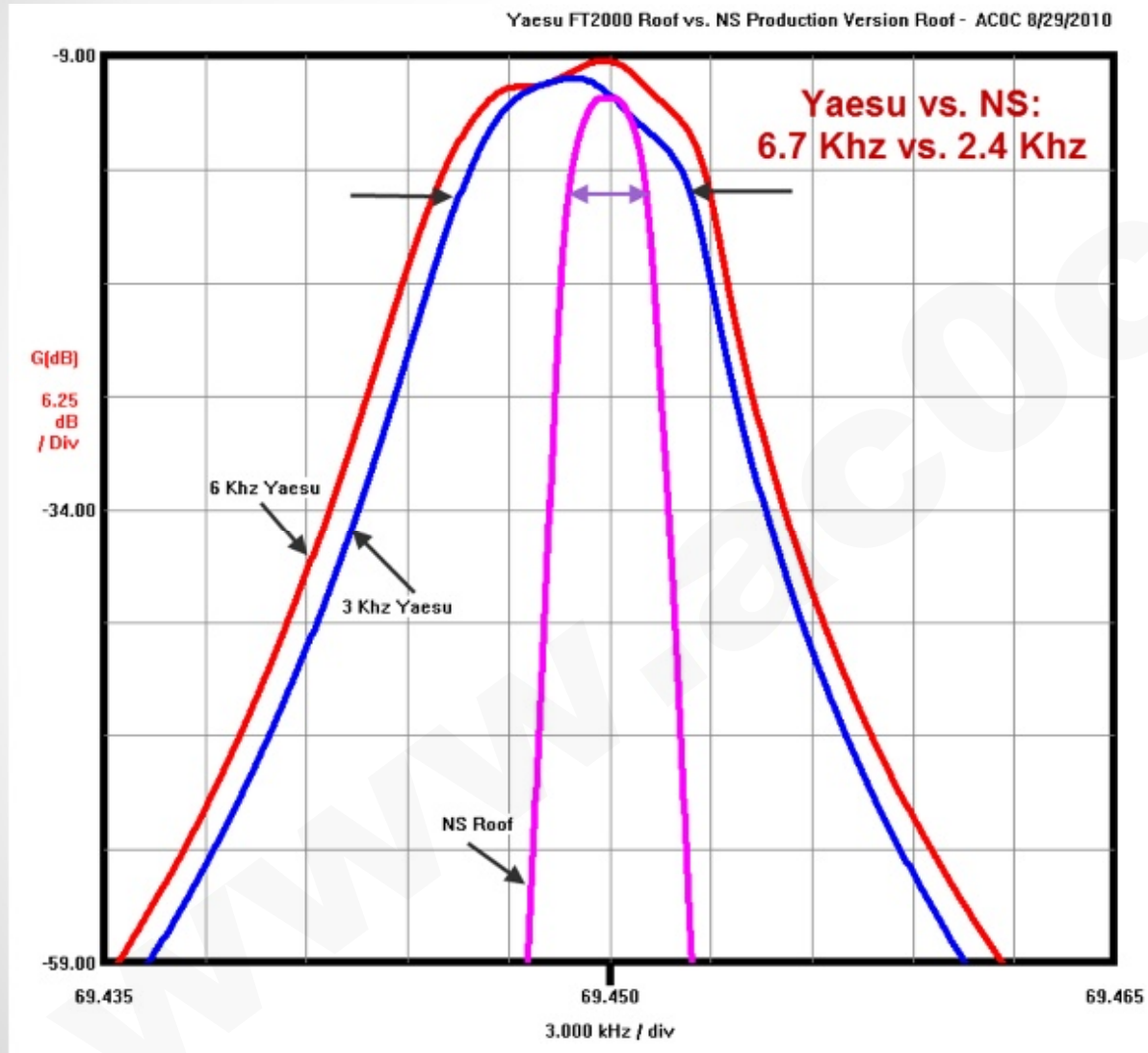


Mod 1: Main RX 2.4 KHz NS Roofing Filter

What the 3rd Mixer Sees – 2.4 KHz NS roof – Significant sig reduction → IMD ▼



Mod 1: Main RX 2.4 KHz NS Roofing Filter



- 3/6 KHz OEM filters:
6-7 KHz @ -6 db
15-18 KHz @ -50 db
- NS roofing filter:
2.4 KHz @ -6 db
5.6 KHz @ -50 db
- Single signal selectivity for SSB
- Improves DR3 on all spacing's from 600 Hz and up

Mod 1: Main RX 2.4 KHz NS Roofing Filter



Example

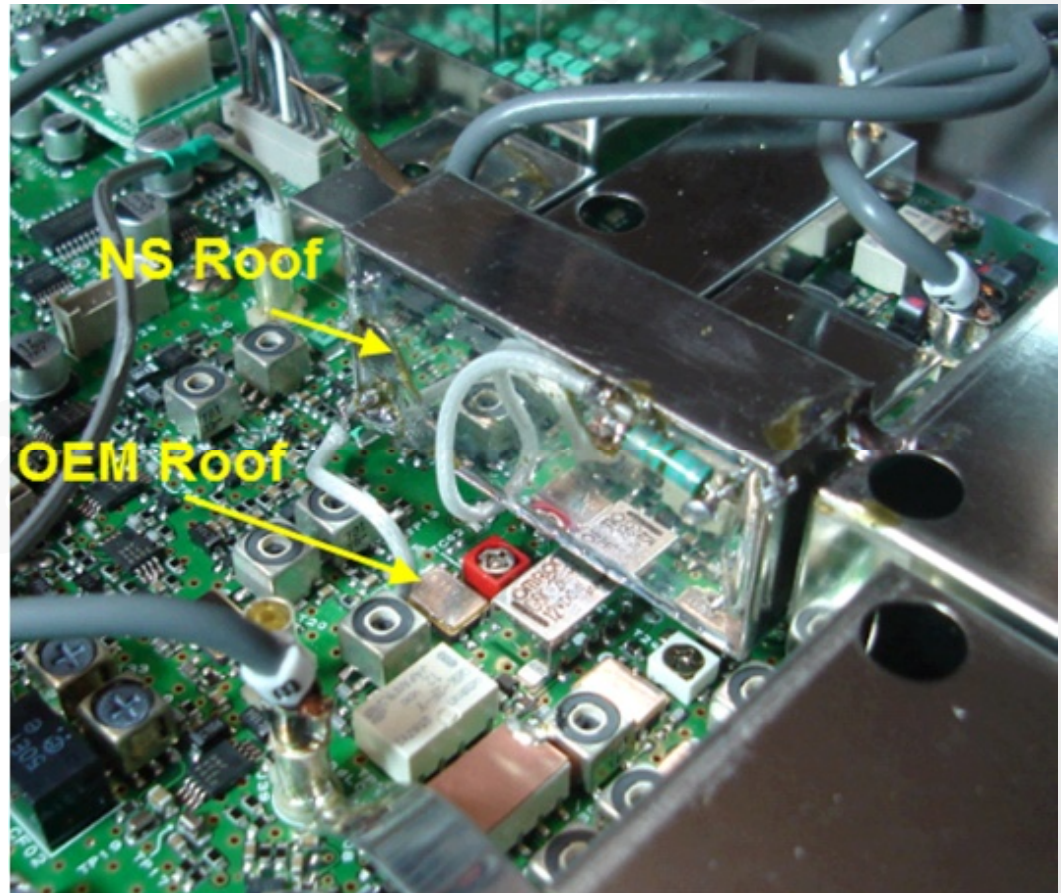
- Lot 19 FT-2000D
- Measured values shown:
- 3 KHz OEM Filter
 - 6.3 KHz @ -6 db
 - 18.5 KHz @ -50 db
- 2.4 KHz NS Filter
 - 2.2 KHz @ -6 db
 - 5.3 KHz @ -50 db

Mod 1: Main RX 2.4 KHz NS Roofing Filter

- Other benefits
 - Essentially eliminates AGC pumping / desense
 - Sweeter CW note
 - Improved DSP filter performance
 - Improved DSP DNR performance
 - Quieter, less fatiguing

Mod 1: Main RX 2.4 KHz NS Roofing Filter

- Mod details:
 - Remove 1 resistor
 - Cut trace
 - Mount L/C on filter
 - Mount coax to filter
 - Connect coax to RX
- SMT
 - Good lighting
 - Good magnification
 - Steady hands



Mod 2: Use ATTN

- No soldering iron required
- Free DR3 improvement
- Set IPO mode (preamps off)
- Add ATTN
- DR3 increases by 3x the selected attenuation value



Mod 2: Use ATTN

What the 3rd Mixer Sees – With varying ATTN



- Effect of ATTN on IMD product levels ~ 3:1 ratio

ATTN	IMD Level
-6 db	▼ 15 db
-12 db	▼ 30 db
-18 db	▼ 45 db



Mod 2: Use ATTN

What the 3rd Mixer Sees – With varying PRE



- Effect of PRE on IMD product levels ~ 3:1 ratio

PREAMP	IMD Level
IPO (no pre)	<Baseline>
PRE 1 (+11 db)	▲ 30 db
PRE 2 (+17 db)	▲ 50 db



Mod 2: Use ATTN

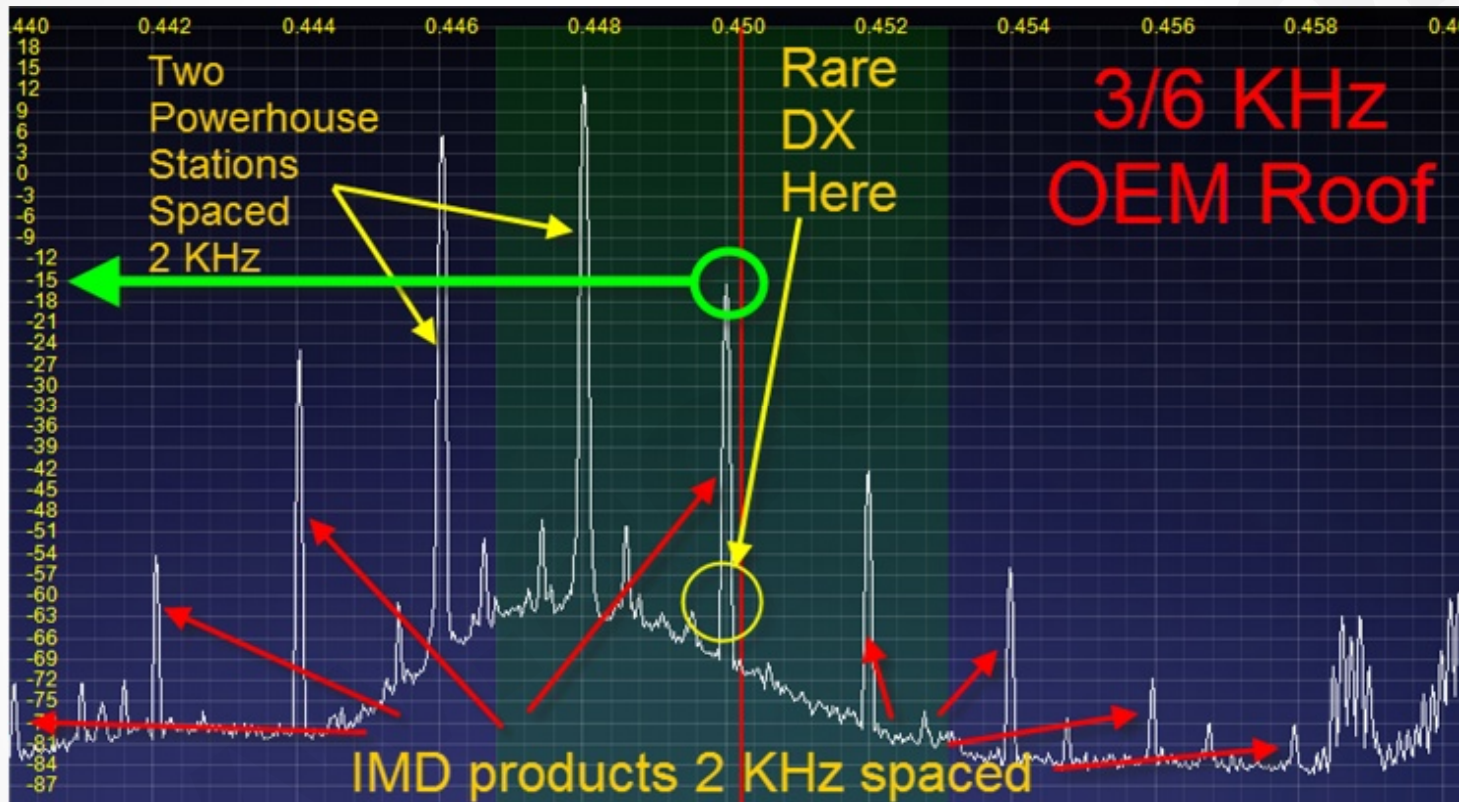
Lot 19 FT-2000D @ AC0C tested 7/21/2011

Band	Attn	DR3 Increase	Net DR3 @ 2 KHz Sp
160m	12-18 db	36-54 db	99/117 db
80m	12 db	36 db	99 db
40m	6-12 db	18-36 db	81/99 db
20m	6 db	18 db	81 db
15m	0-6 db	0-18 db	63/81 db
10m	0	0	63 db

- Shows ATTN switch range possible without loss of useable sensitivity
- With just 6db, DR3 performance jumps to 81 db!
- Table ignores phase noise limits

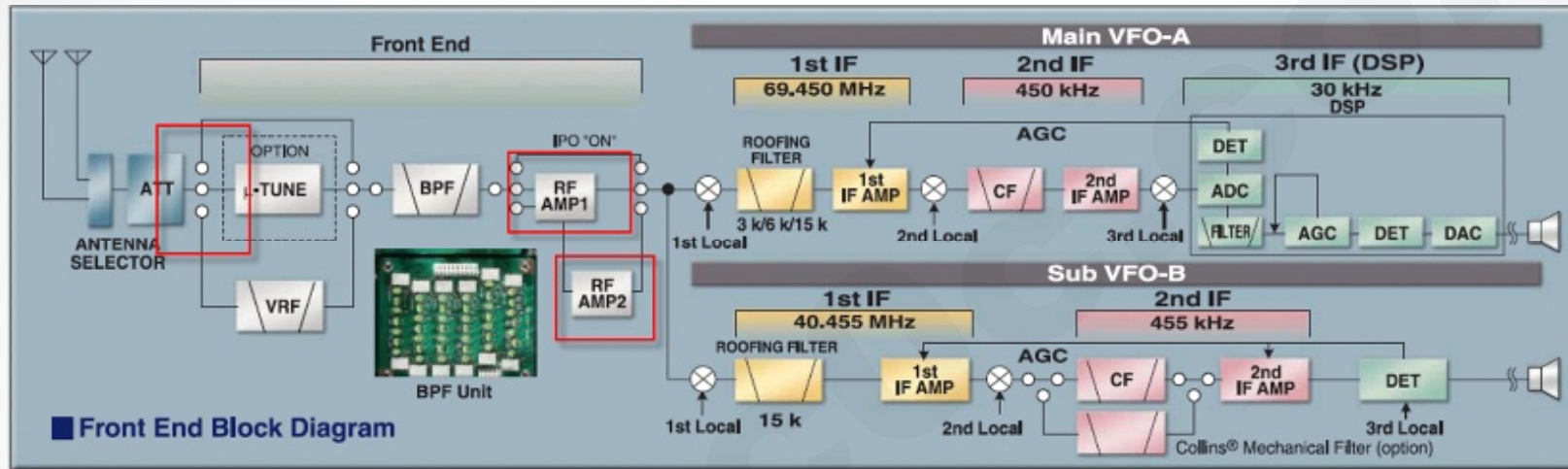
Mod 2: Use ATTN

What the 3rd Mixer Sees



- Use IPO whenever possible
- Add ATTN when strong sigs are close

Mod 3: Harden Preamp/Mixer



- Additional protection against preamp/mixer damage
- Root cause - high RF or static levels on the antenna inputs
- **Applies to LOT 44 and earlier rigs only**
- Mod based on published component value changes over lot numbers
- Causes the protection relay to engage faster
- Changes bias point in the preamps

Mod 3: Harden Preamp/Mixer

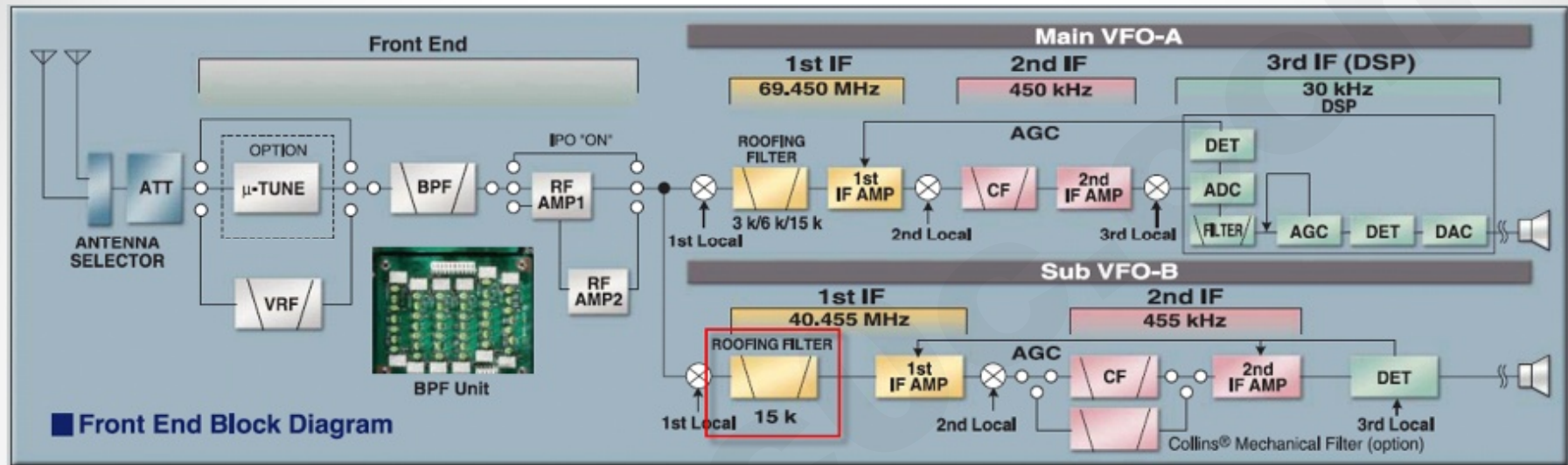
- ANT Board Component Changes

Item	Old value	New Value	Applies to Lot #
C2704	22 pf	remove	1-31
C2705	2p	3p	1-31
C2707	0.047 uF	0.001 uF	1-31
R2705	100K	4.7K	1-42
R2707	22	0 (short)	1-42
R2713	56/5W	39/5W	1-26

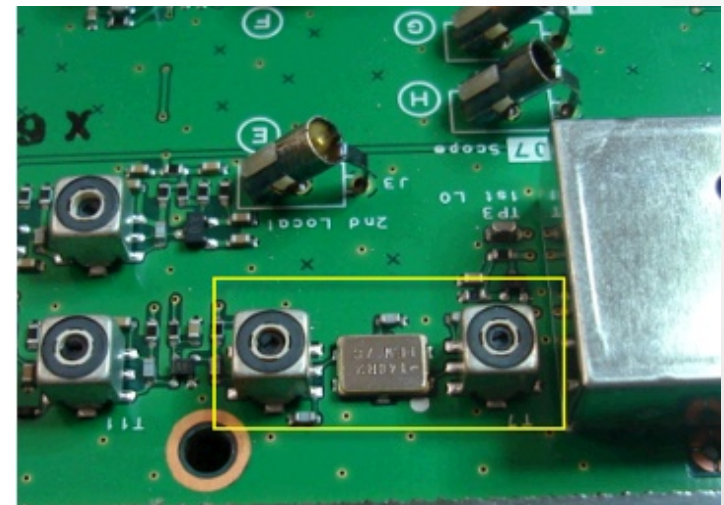
- MAIN RX Board Component Changes

Item	Old Value	New Value	Applies to Lot #
R1180	150	47	1-44
R1181	150	47	1-44
R1196	1K	330	1-44
R1198	1K	330	1-44

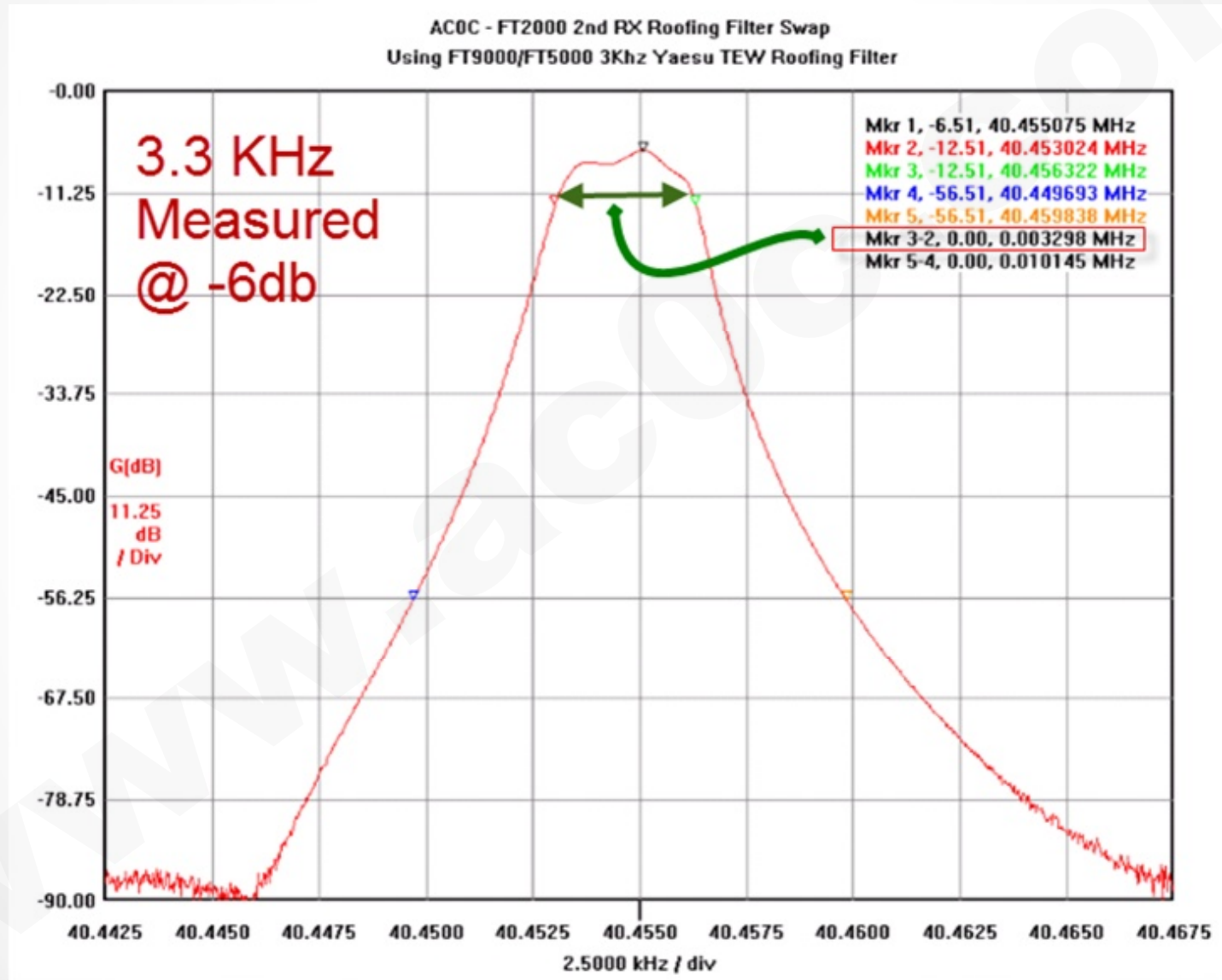
Mod 4: Sub RX 3 KHz Roofing Filter Swap



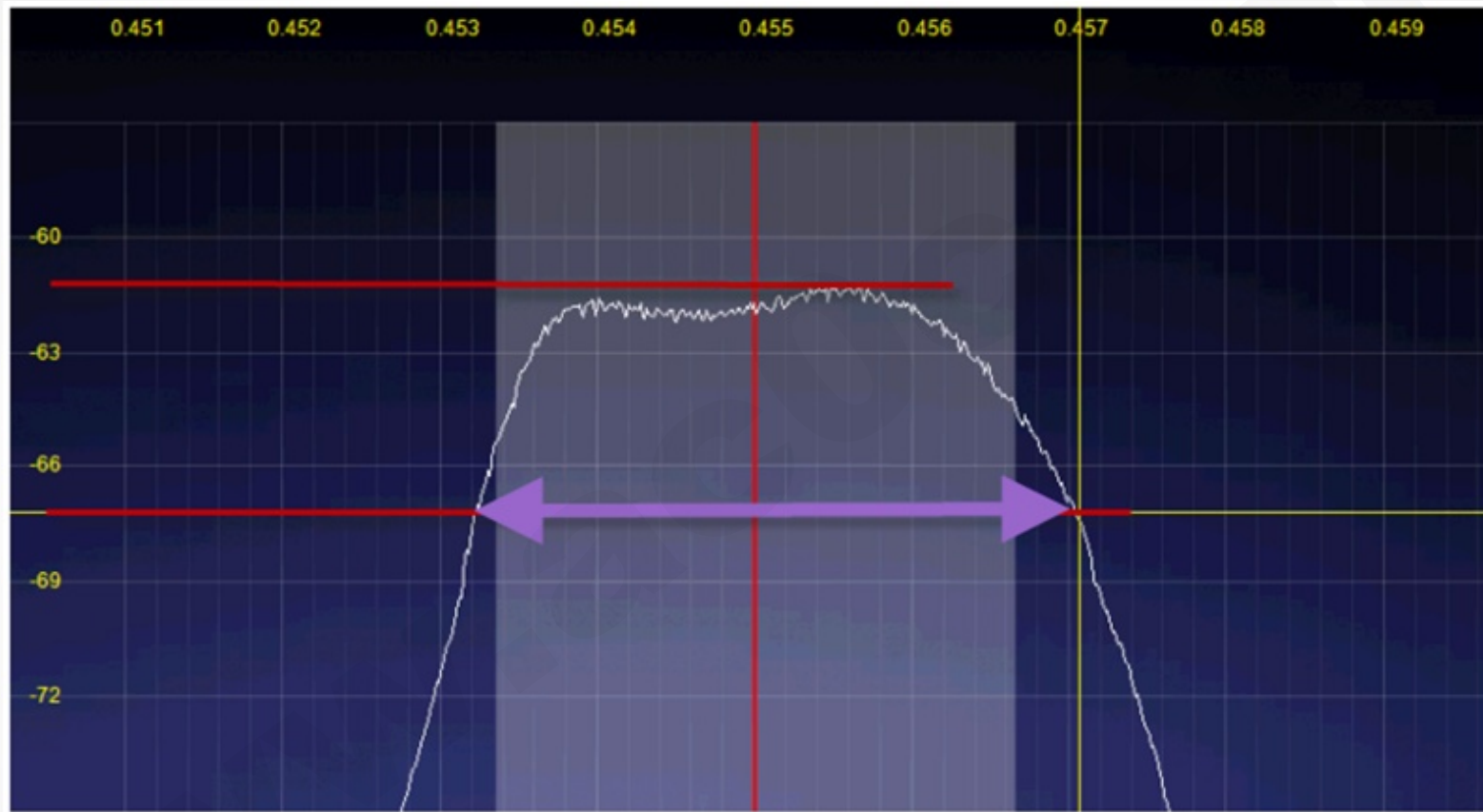
- Replaces OEM 15 KHz filter with 3 KHz roofing filter from the FT-9000
- Up to 15 db increase in DR3



Mod 4: Sub RX 3 KHz Roofing Filter Swap

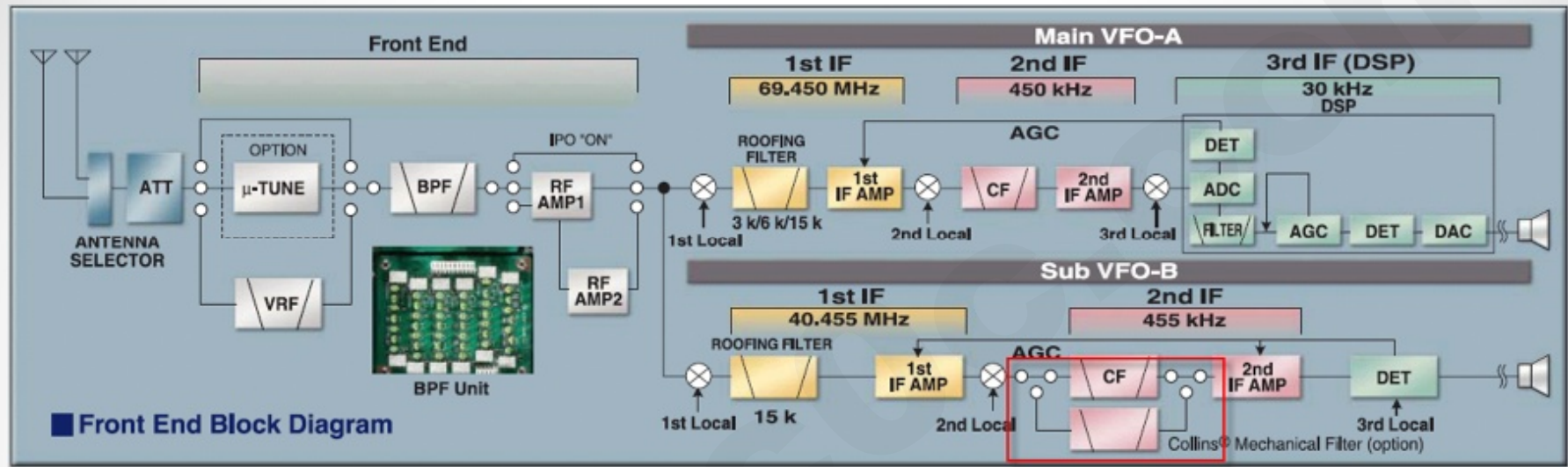


Mod 4: Sub RX 3 KHz Roofing Filter Swap

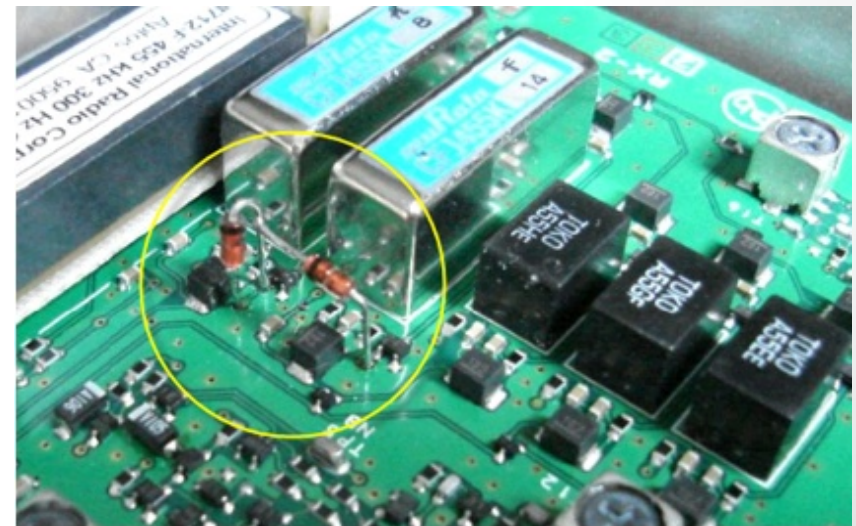


- In-rig measured: 3.6 KHz measured bandwidth @ -6 db

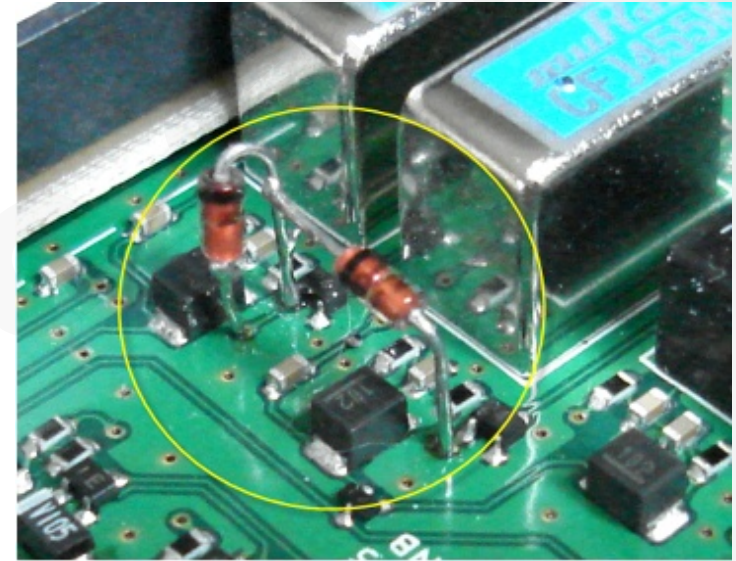
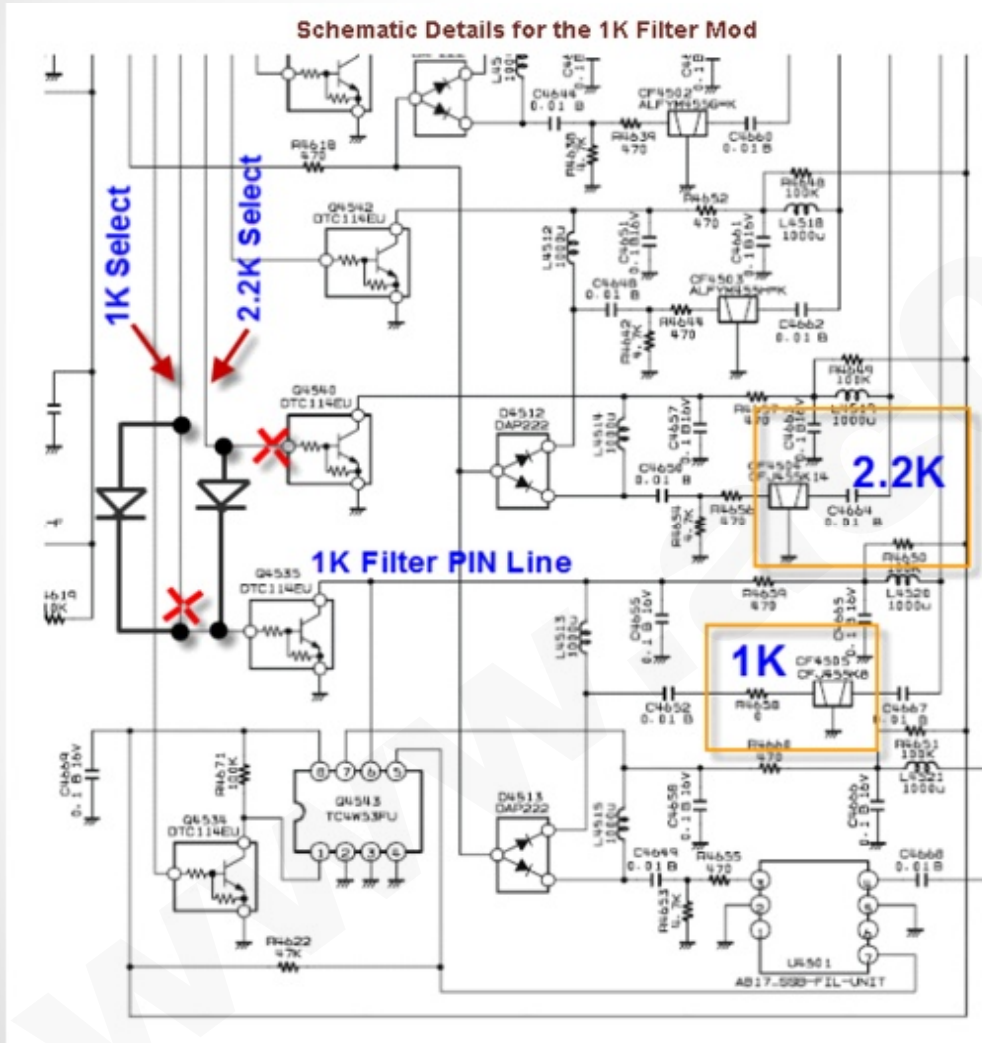
Mod 5: Sub RX Filter Logic



- Forces selection of tighter 2nd IF tighter in SSB/CW/PSK/RTTY modes
- 2 diode mod is easy to do and reversible

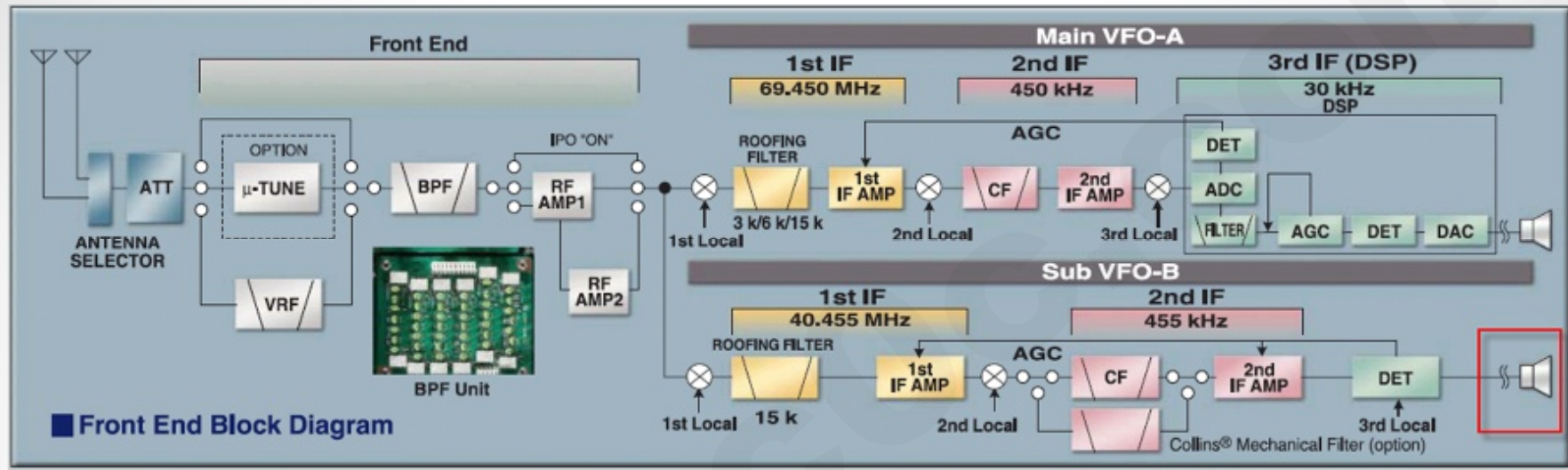


Mod 5: Sub RX Filter Logic



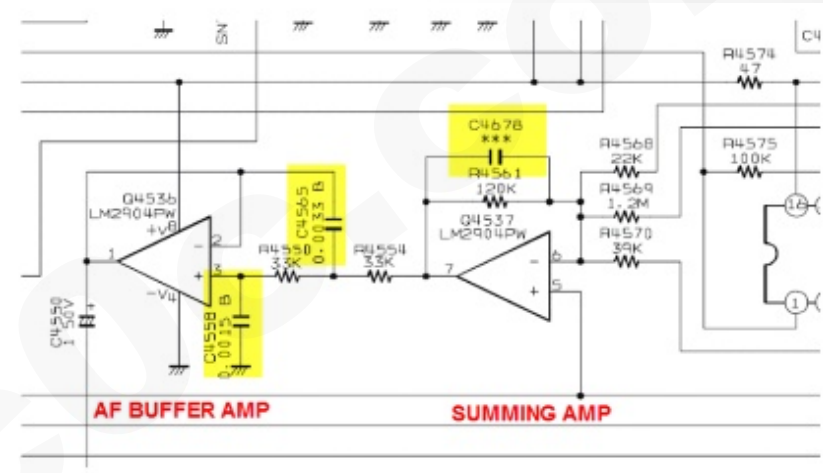
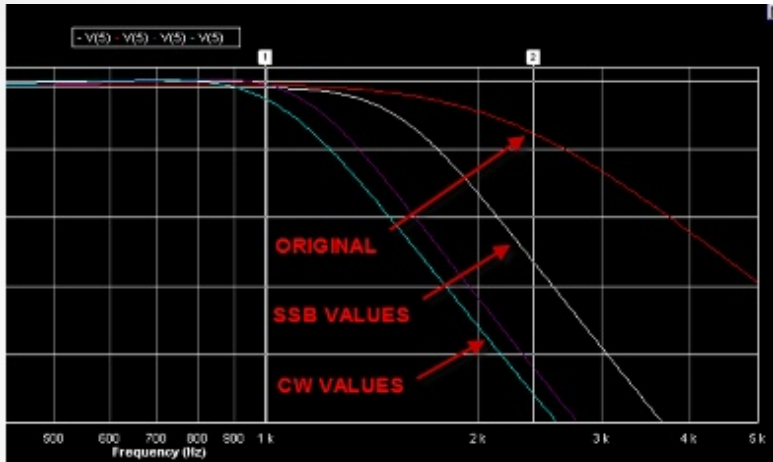
- Typical performance
- STD: 2.3 KHz @ -6db
- Mod: 1.6 KHz @ -6 db
- Quieter, less fatigue, less QRM

Mod 6: Sub RX AF Filtering



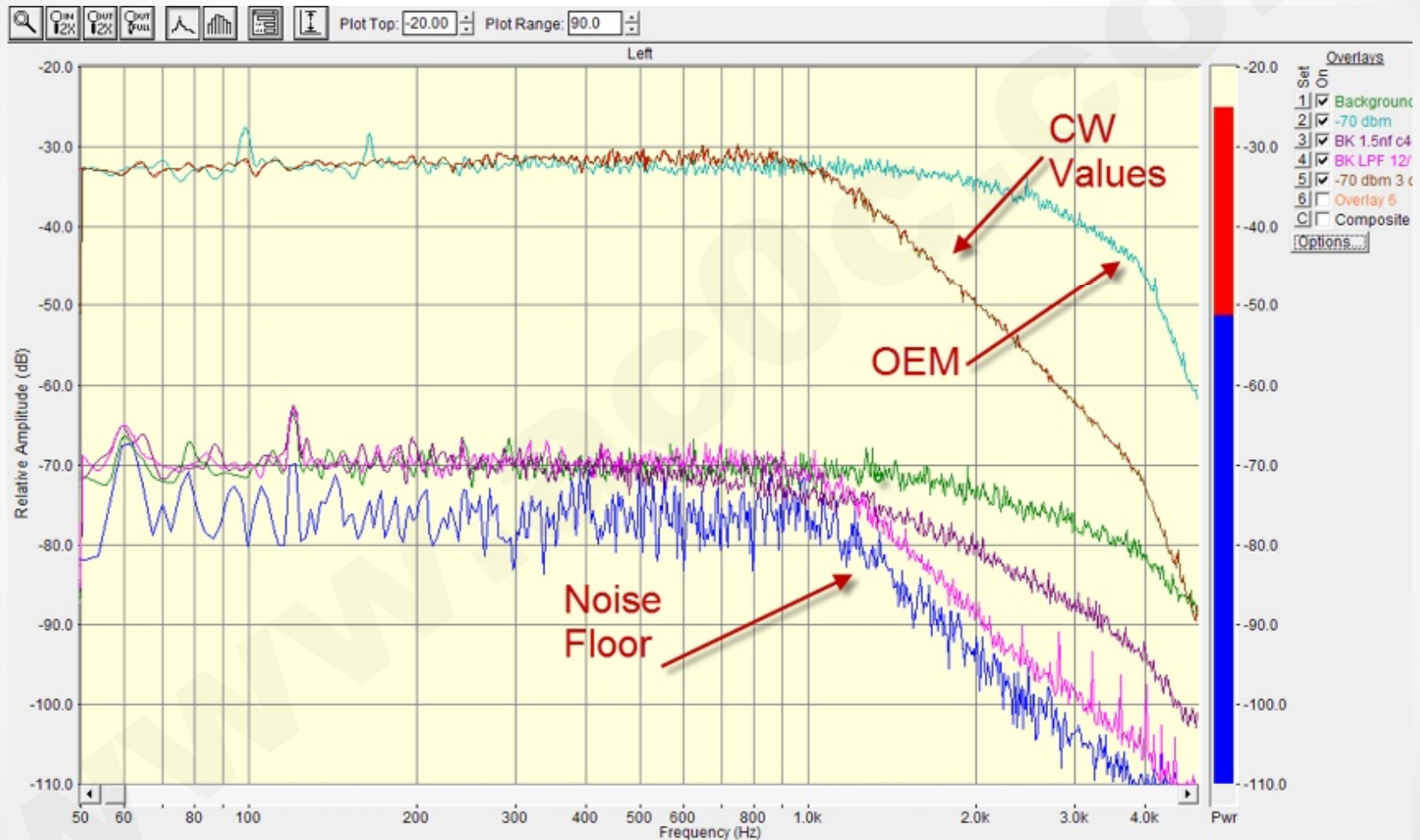
- Benefit: Minimizes hiss → less user fatigue
- Via: Moves the LPF CF down; increases rolloff rate
- Work required: Add 3 SMT caps to sub RX PCB

Mod 6: Sub RX AF Filtering



Component	Original Values	CW 1 KHz	CW 900 Hz	SSB 1.6 KHz
C4558	1500 pF	1800 pF	1800 pF	1200 pF
C4565	3300 pF	0.0012 uF	0.0012 uF	8200 pF
C4678	{none}	1500 pF	1500 pF	1200 pF

Mod 6: Sub RX AF Filtering



The Mods in Review



FT-2000 Mods - In Review

Item	Mod Summary	Ease	Cost	Comment
Main RX: 1 st IF roof 6-7 Khz	Swap with 2.4 Khz NS filter	5	\$300	Up to 20 db increase in DR3 @ 2 KHz sp
Use ATTN	None	1	Free	DR3 increase equal to 3x ATTN setting
Harden Mixer/Preamp	Component value changes	8	\$10	Eliminates most overload failures caused by large RF fields or static build-up
Sub RX: 2 nd IF roof 15 Khz	Swap with FT-9000 3 Khz roof	7	\$20	Up to 15 db increase in DR3 @ 2 KHz sp
Sub RX: 2 nd IF filters wide	Diode switch to force tighter filter selection	4	\$1	Forces 1.6 Khz BW filter inline with SSB/CW/RTTY/PKT in "WIDE" setting
Sub RX: Hiss	Component value changes	4	\$1	Hiss reduction
Firmware update	Flash control and DSP firmware	2	Free	Load updated firmware – especially the post PEP versions

What about the FT-dx5000?

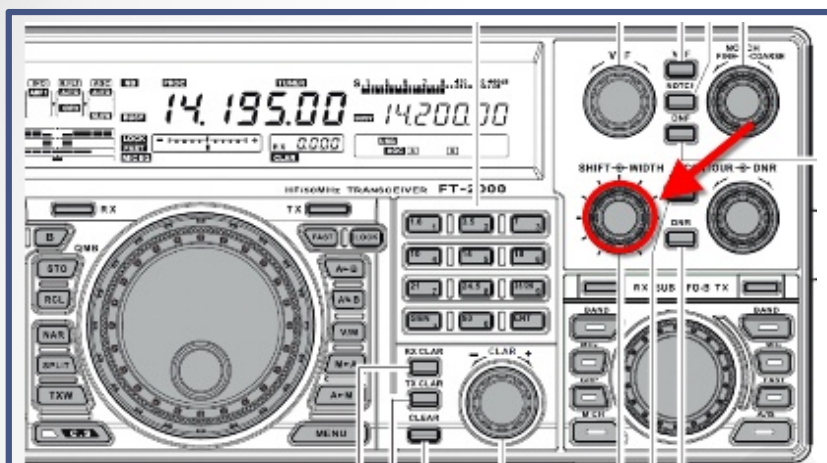
www.iacoc.com

FT-2000 Compares Well vs. FT-dx5000

Metric	FT-2000	FT-5000
Cost	\$2500 w/NS filter	\$5000
DR3	OK	Excellent
Ergonomics	Excellent	OK (SO1R) Poor (SO2V)
DNR	OK	Excellent
NB	Poor	OK
APF	Excellent	OK
Sub RX	OK	Excellent
Power	100W	200W

- Bottom Line
 - FT-5000 wins the close-in battle, but ergonomics are a severe op handicap
 - FT-2000 w/NS filter - better overall – especially for SO2V

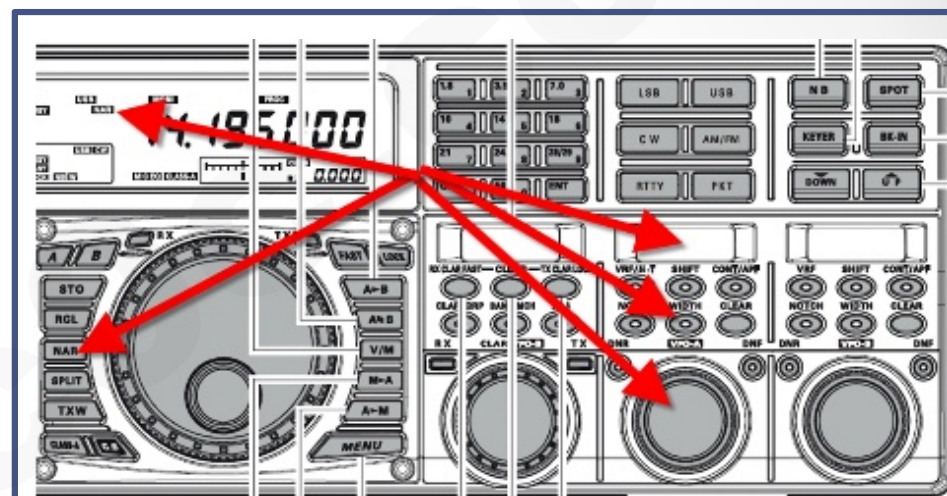
FT-2K vs. FT-5K Ergonomics Example: NAR function – FT-2K Range Overlap Simplifies Use



MODE	NAR OFF	NAR ON*
LSB/USB	200-4.0kHz	Fixed 1.8 KHz
CW	25-2.4kHz	25-2.0 KHz
RTTY (LSB)	25-2.4 KHz	Fixed 300 Hz
PKT (LSB/USB)	25-2.4 KHz	Fixed 400 Hz

2K

To change width:
1. Turn control CCW



MODE	NAR SWITCH	
	OFF	ON
LSB/USB	1.8 kHz - 4.0 kHz / 16 steps (2.4 kHz*)	200 Hz - 1.8 kHz / 9 steps (1.8 kHz*)
CW	500 Hz - 2.4 kHz / 7 steps (2.4 kHz*)	50 Hz - 500 Hz / 10 steps (500 Hz*)
RTTY(LSB)	500 Hz - 2.4 kHz / 7 steps (500 Hz*)	50 Hz - 500 Hz / 10 steps (300 Hz*)
PKT(LSB/USB)	500 Hz - 2.4 kHz / 7 steps (500 Hz*)	50 Hz - 500 Hz / 10 steps (300 Hz*)

*: Default (the [WIDTH] button glows red)

To change width:

1. Check width function selected, if not press button
2. Turn VFO-A control CCW
3. **If 500 Hz still too wide, press NAR button**
4. **Continue VFO-A adjustment**

5K

Mod Details

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