

Band-Tunable TV Mask Filters and FM combiners

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WBA Broadcasters Clinic October 2015



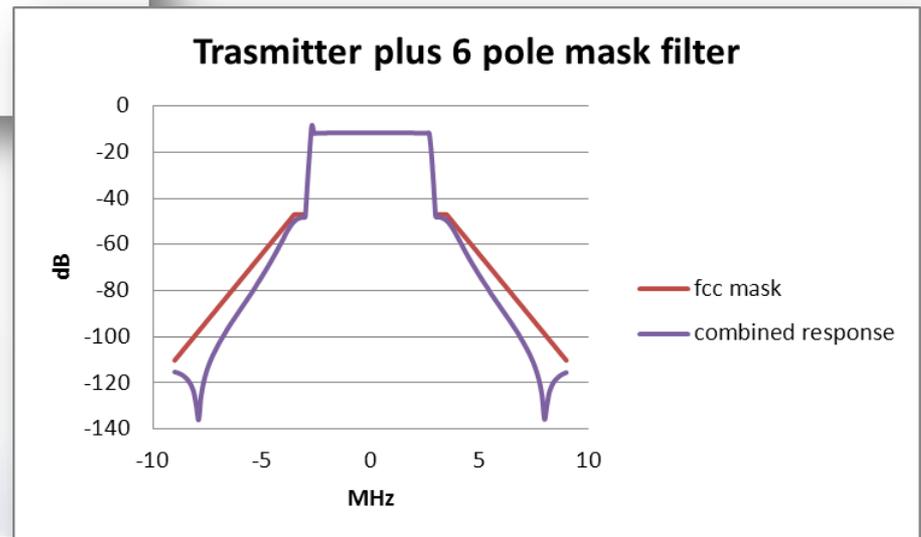
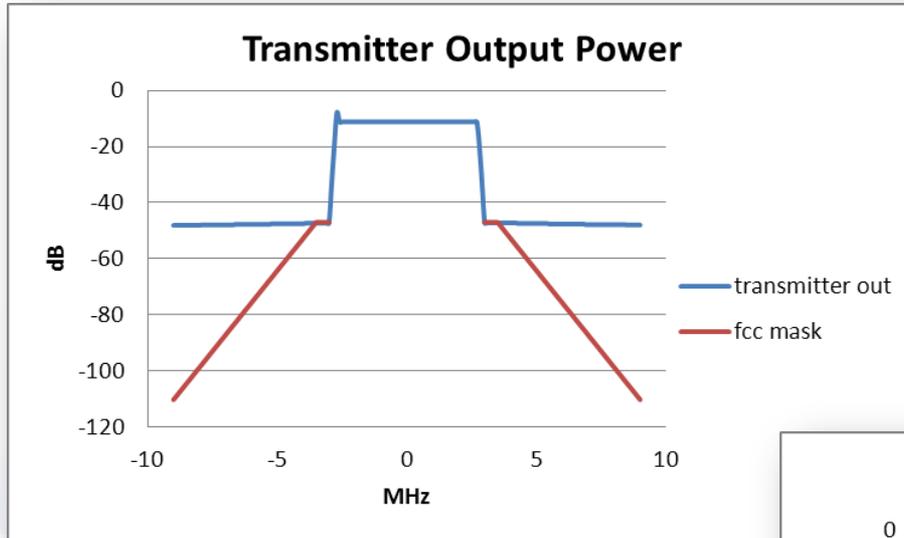
Tunable UHF filters 100 W to 6 kW (ch 14 to E69)

New 20 kW band tunable mask filter (ch 14-51)

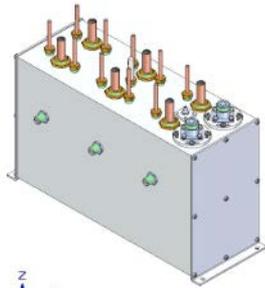
FM Combiners

Filter Tuning

Why Mask Filters ?



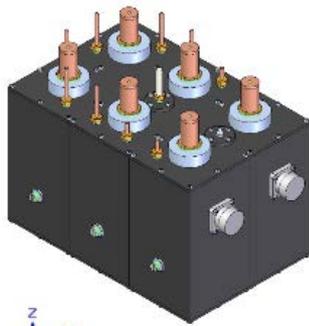
Powerlite Series of Filters



100-250 Watt



3000 Watt
With water
cooling to
7000 W



600 Watt



1500 Watt

Why Band-tunable ?

- Accommodate channel change
- Transmitter is band-tunable
- Transmitter / Filter can be moved from one site to another
- Transportable backup transmitter is feasible
- Common parts for wide channel range
 - Volume manufacturing
 - Parts can be stocked

Why higher power tunable filters ?



Cylindrical
Waveguide
Constant
Impedance
Filter (CIF)
1200 pounds
(544 kg)

CHANGING CHANNEL ?

New Product



- 10 kW (air cooled)
- 20 kW (water cooled)
- 3 1/8" and 4 1/16" connections
- Tunable filter
 - Channel 14-51

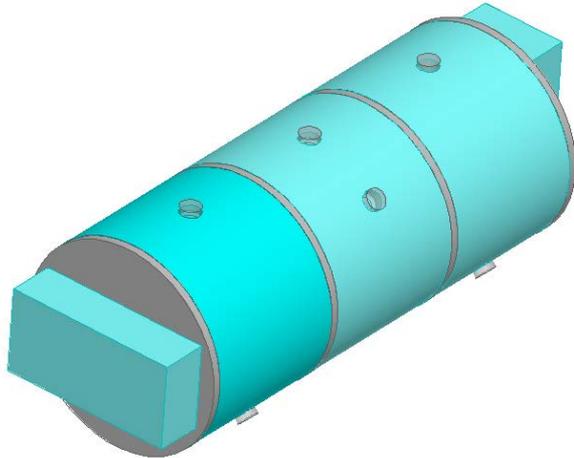
Weight 105 lbs (48 kg)

Why higher power tunable filters ?



- New Solid State Transmitters Approach IOT Efficiency
- Liquid Cooled Transmitters are Becoming More Accepted
- Mask Filters are Generally Average Power Limited (heat)
- Liquid Cooling Available for Filter Using Tx Heat Exchanger
- Additional Heat Load from Filter is about 1 kW
- Solid State Transmitters are OK with Reflective Filter
- IOT Transmitters Need CIF for proper functioning
- Current Solid State Offerings easily band tunable
- Channel 14-51 chosen to accommodate US spectrum auction and channel repack

Why higher power tunable filters ?



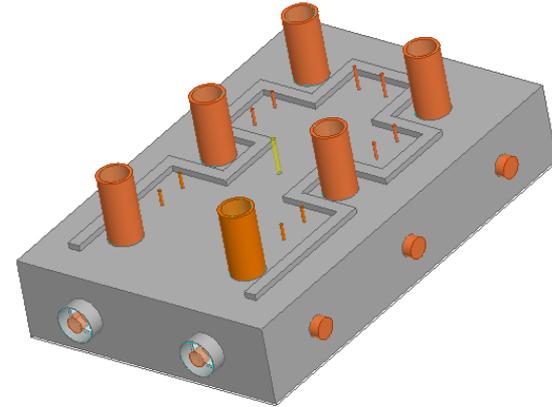
Dual Mode Cylindrical Waveguide Filter

Advantages

- Low Loss (~97% efficiency)
- Free Convection Cooling

Dis-Advantages

- Large, Heavy
- Cavities cut to order



Coaxial Cavity Band Tunable Filter

Advantages

- Smaller, Lighter
- Parts can be stocked

Dis-Advantages

- Higher Loss (~93% efficiency)
- Requires water cooling

New Filter Specs

Channel Range	14-51
Number of Poles	6
Mask	ATSC full
I/O connectors	3 1/8" or 4 1/16"
Input Power Rating	20 kW or 25 kW
Insertion Loss	0.27 dB max fc 0.38 dB max ± 2.69 MHz
Effective Loss	0.29 dB max (93%-95% efficiency)
Group Delay Var.	150 ns ($fc \pm 2.69$ MHz)
Input Return Loss	26 dB min ($fc \pm 2.7$ MHz)
Ambient Temp Range	0°C to 40°C (32°F to 104°F)
Max Water Temp	35°C (95°F)
Temp Rise at Full Pwr	27-63°C (80-145°F)
Size	40 in x 25 in x 15 in (102 cm x 64 cm x 38 cm)
Weight	105 lbs (48 kg)



Power Testing



At Dielectric
Factory at
9kW ATSC and
9kW DVB-T
(6 MHz)

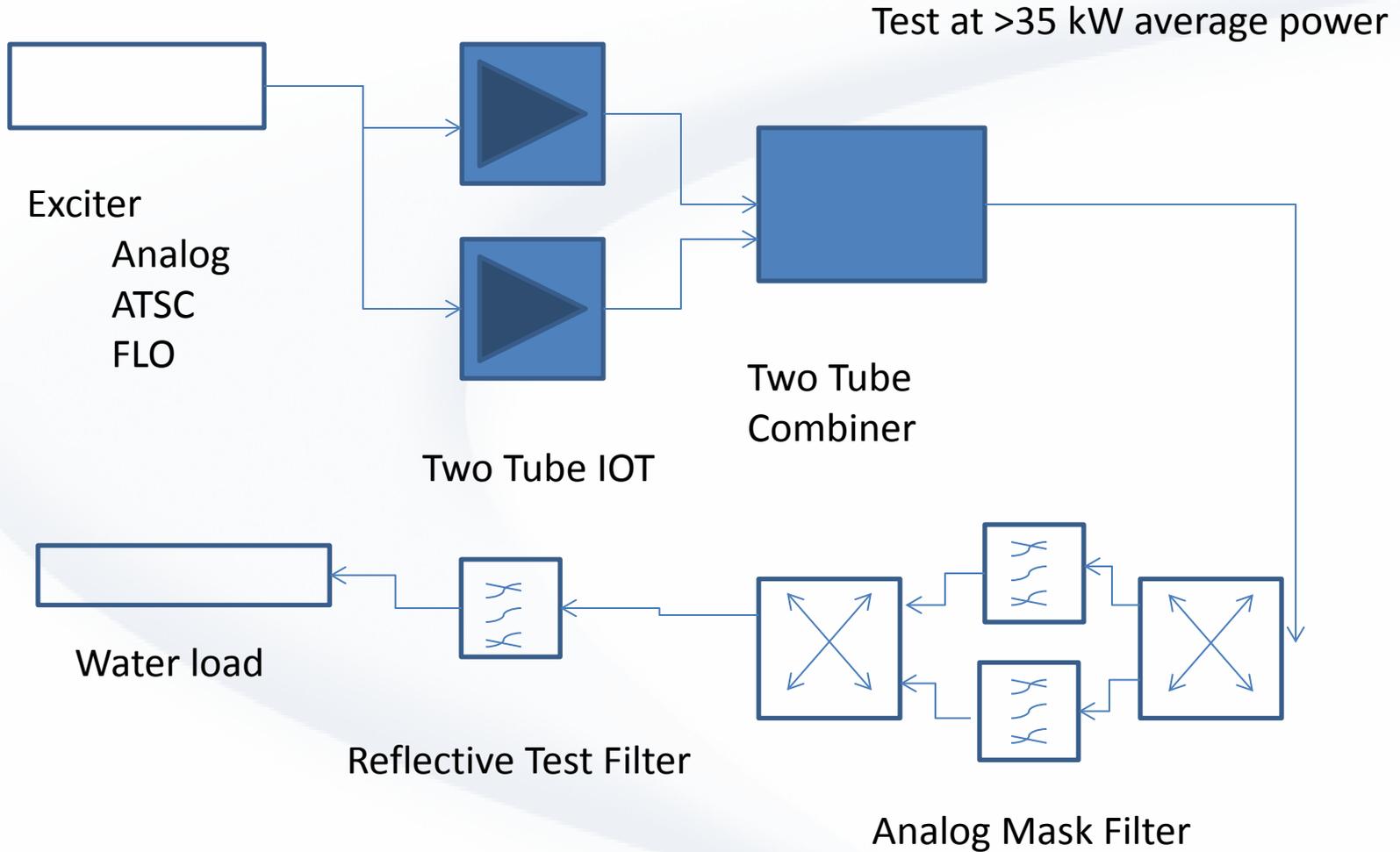
Power Testing



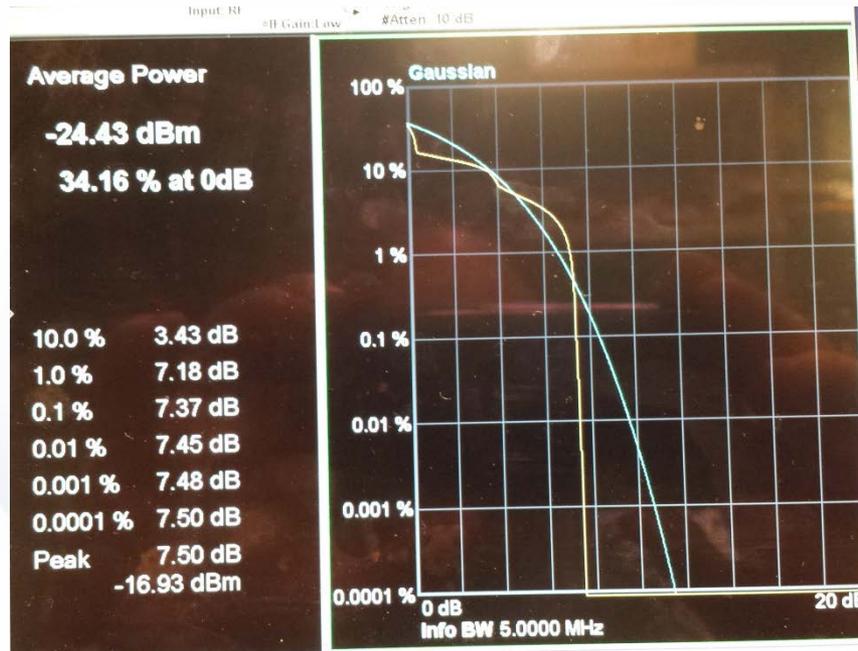
At WPFO – Litchfield, ME
Special Thanks
WPFO/WGME (Sinclair)



Power Testing - WPFO

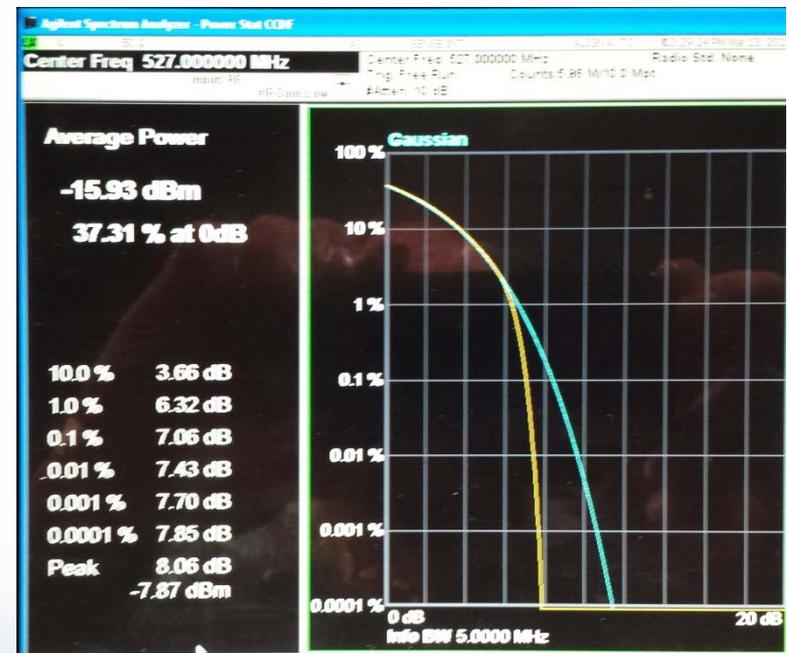


Power CCDF



Analog (w/ adjusted aural and APL)

DVB-T



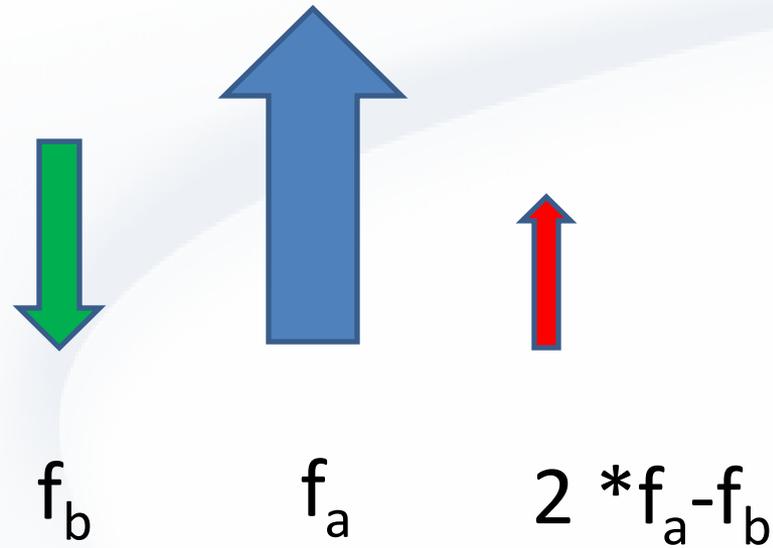
FM Channel Combiners

- *Allow multiple FM stations to broadcast from the same antenna*



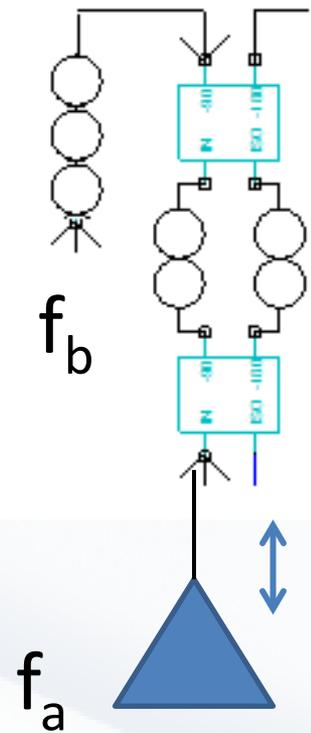
2-10 channels; 3 kW to 60 kW per station

Intermodulation products in FM transmitters



IM product falls in FM broadcast or air navigation band
Can interfere with neighboring broadcasters or airports

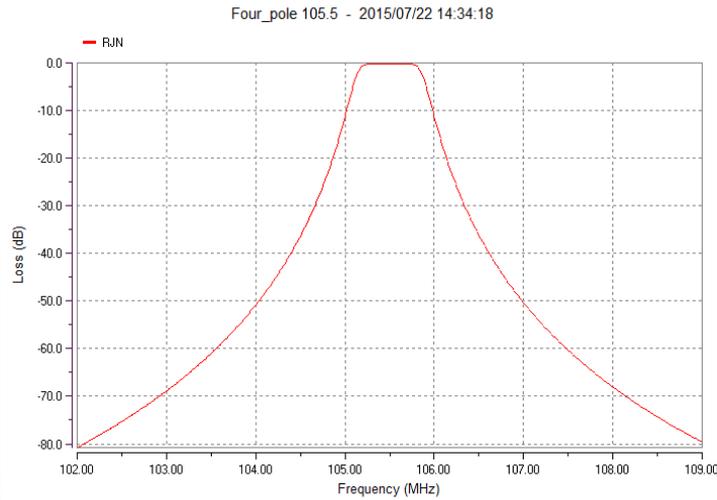
Filter Rejection Controls IM level



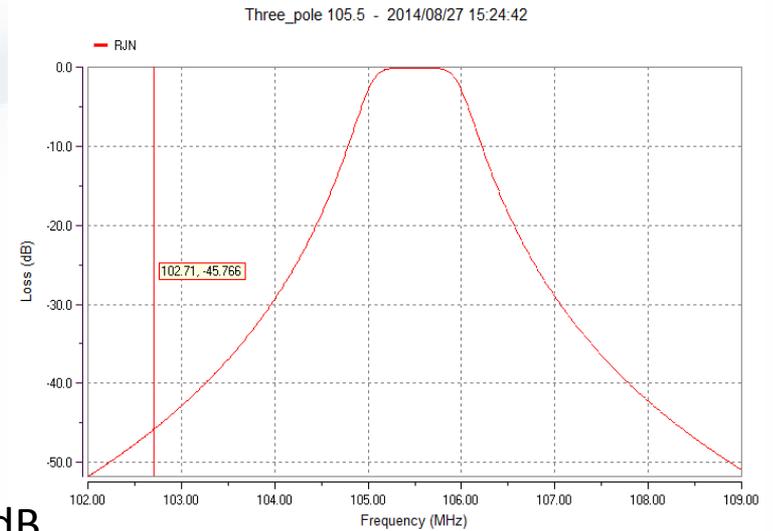
$$f_a + f_b + 2 * f_a - f_b$$

Turn around loss
transmitter

Filter Rejection



4 pole filter response



3 pole filter response

Filter Rejection and combiner channel spacing



FM Filter Rejection

# of poles	dB Rejection at spacing from fo							
	0.8 MHz	1.2 MHz	1.6 MHz	2.0 MHz	2.4 MHz	2.8 MHz	4.4 MHz	10.2 MHz
2	1	4	8	11	14	17	25	50
3	12	22	30	36	40	45	57	> 80
4	30	43	54	62	68	73	> 80	> 80
5	45	65	78	87	95	102	>80	>80

IM rejection calculation

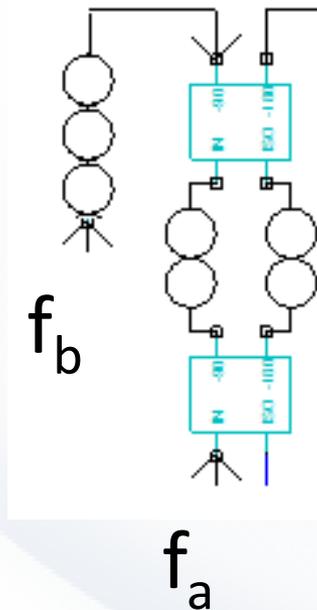
CIF = 2 x Rejection + 30 dB

manifold = 2 x rejection

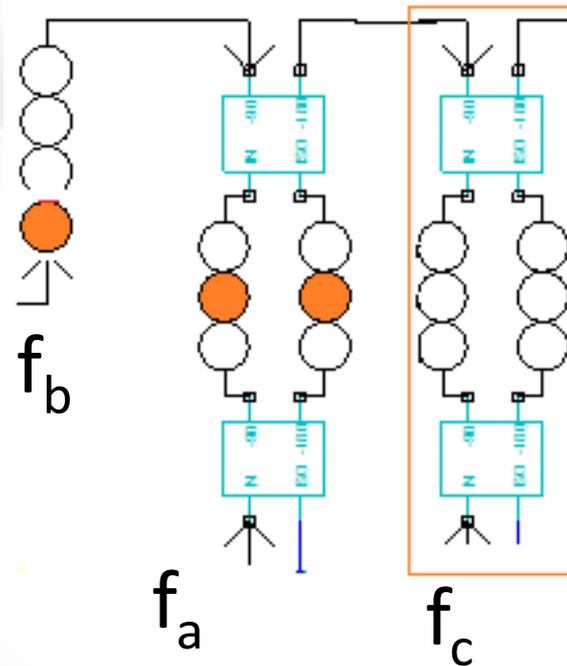
Minimum channel spacing to get -80 dB min IM rejection:

# of poles	spacing in MHz	
	CIF	manifold
2	4.4	10.2
3	1.6	2.4
4	0.8	1.2
5	any	0.8

Combiner upgrade to add new channel



Original combiner
For 4.8 MHz channel
spacing



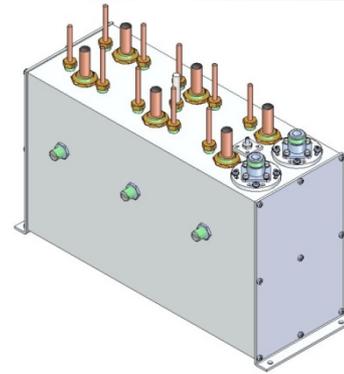
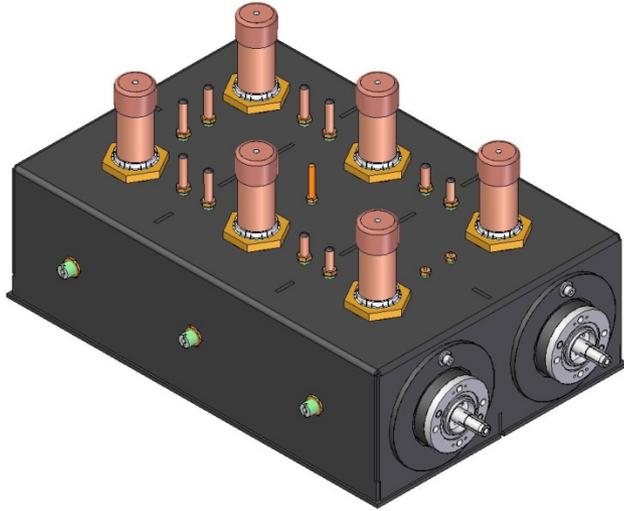
Upgraded combiner
For 1.6 MHz channel
spacing

Common cavities make field upgrade viable

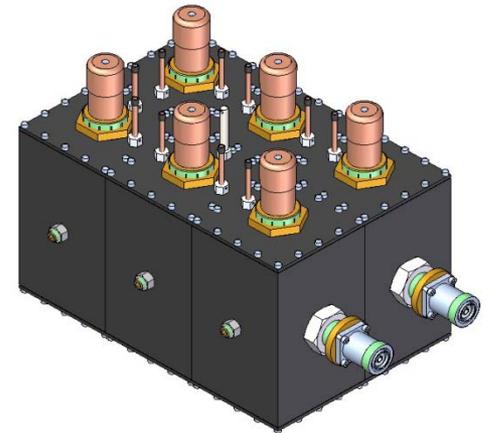


Add filter cavity and change iris plates, retune

Filter Tuning



Patience Required !



Tuning Options

- Buy or rent vector network analyzer (VNA) and try it your self
- Hire qualified field engineer
- Work with station group to use central engineer / VNA and exchange filters
- Return filter to factory for re-tuning



Tuning Procedures



- Available at www.dielectric.com

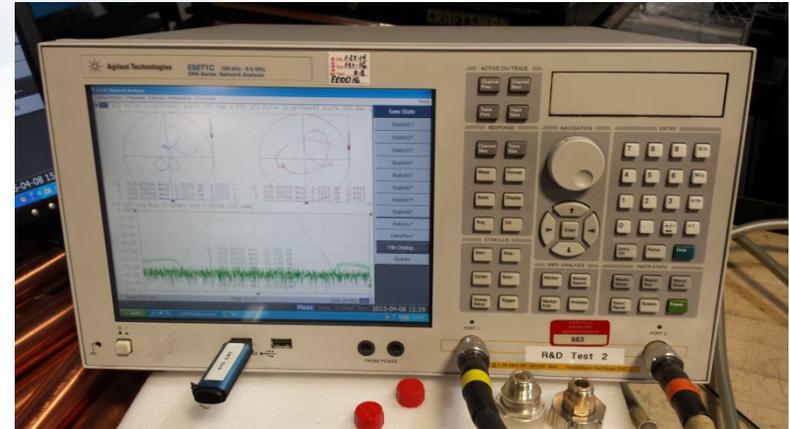
Equipment Needed

Vector Network Analyzer (VNA) purchase

- Keysight Technologies (formerly Agilent)
- Rohde & Swarz
- Anritsu
- Advantest
- Copper Mountain

VNA Rental

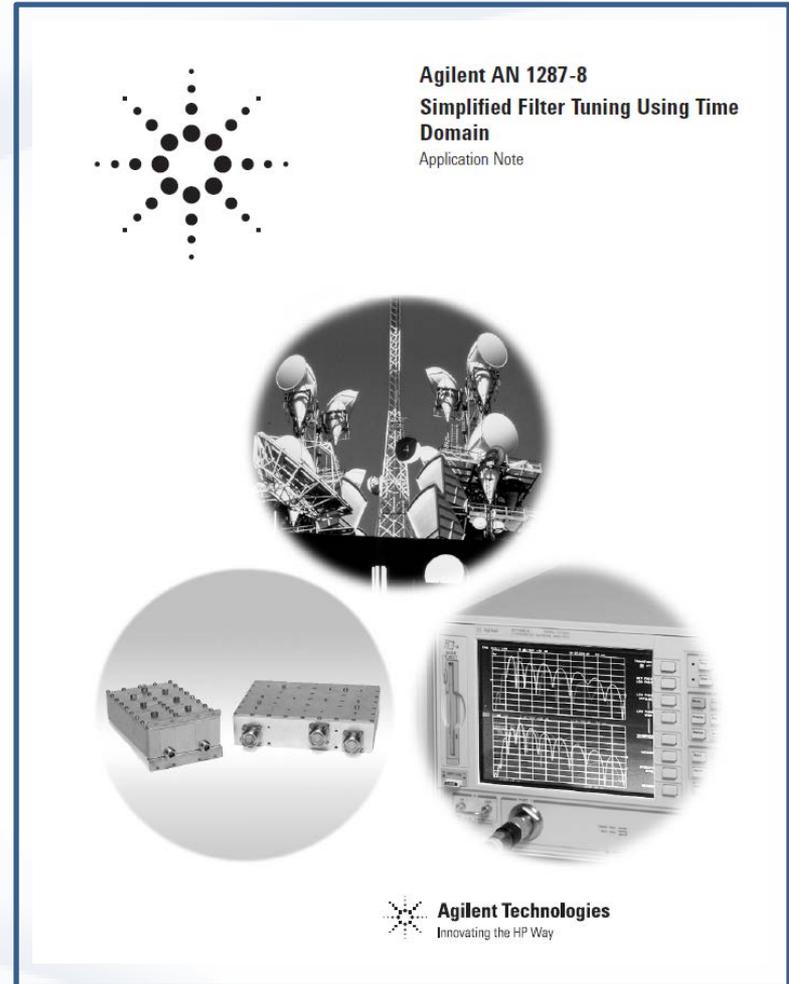
- Electro-rent
- Test Equity
- Advanced Test Equipment Rentals
- Metric Test
- TRS-RenTelco



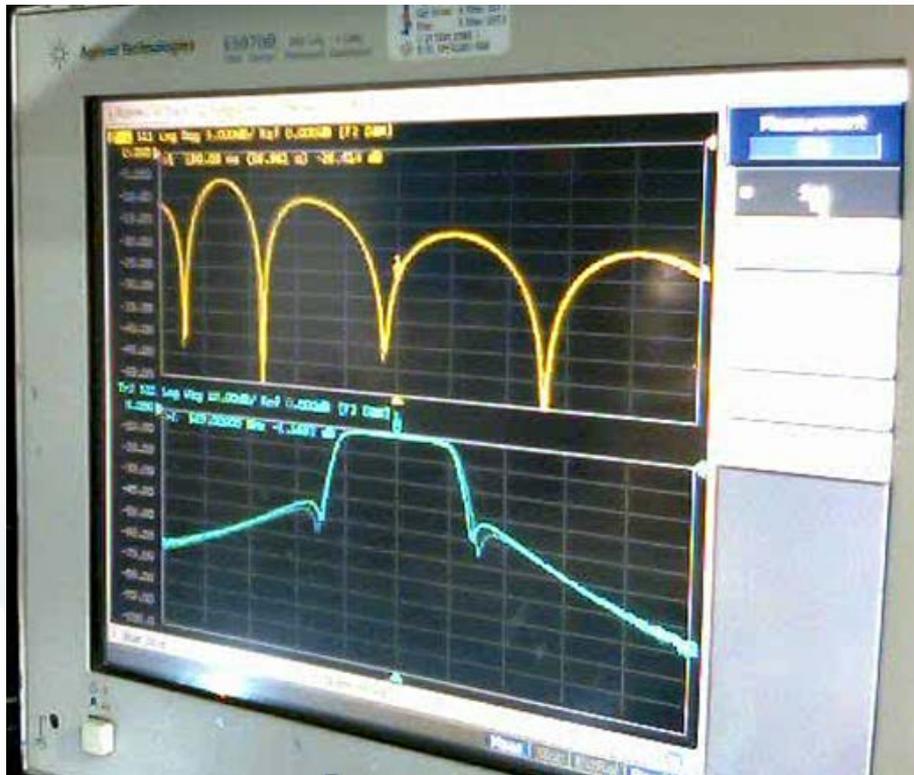
- Calibration Kit and Cables
- Adaptors type N to 7-16
Or type N to 1 5/8" or 3 1/8"
- Allen keys and standard wrenches

Time Domain Tuning

- Time domain tuning
- Agilent (key sight) app note AN1287-8
- Requires VNA with time domain transform (TDR) option
- Response in time domain corresponds to each physical adjustment



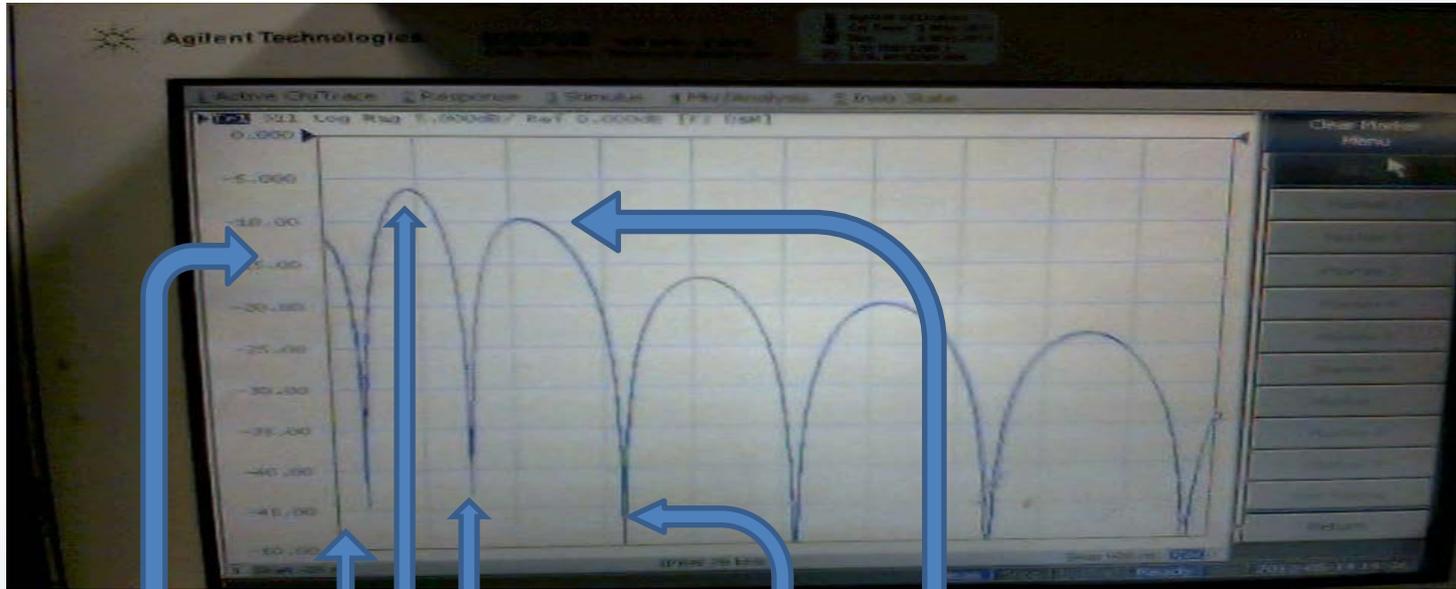
Time Domain Tuning



- Important Step 1: Before making any adjustments on tuned filter save :
- input return loss (S11)
- transmission response (S21)
- output return loss (S22) to VNA memory

These memory traces will serve as template for tuning the filter at the new channel

Time domain – S11 response



resonator 2
1-2 coupling
resonator 3
2-3 coupling

input coupling
resonator 1

- Powerlite filter series (100 W to 7 kW)
 - UHF Band tunable (470-860 MHz)
- New Higher Power tunable filter
 - 10 kW convection, 20 kW water cooled
 - Ch 14-51
- FM Combiners
 - Impact filter has on IM generation
 - Combiner upgrade to add channels
- Filter Tuning
 - Field Engineer or station group RF expert
 - Having spare filter for station group makes sense

Questions

