Combining Six High Power FM Broadcast Stations into one Master antenna

Ed Allen, CPBE, DRB

WA4ISB

American Tower, Riverview 1

1,593’ AGL, 1,668’ AMSL

6 FM Stations
88.5 WMTX
93.3 WFLZ
94.9 WWRM
100.7 WMTX
101.5 WPOI
103.5 WFUS

5 Full power TV Stations
WTSP Virtual channel 10, RF channel 10
WCLF Virtual channel 22, RF channel 21
WMOR Virtual channel 32, RF channel 18
WFTT Virtual channel 62, RF channel 25
WXPX Virtual channel 66, RF channel 29

5 Low Power TV stations
WBKH Virtual channel 17, RF channel 27
WSVT Virtual channel 18, RF channel 23 (Not on air)
WTAM Virtual channel 30, RF channel 35
WSPF Virtual channel 35, RF channel 36
WTBT Virtual channel 45, RF channel 45

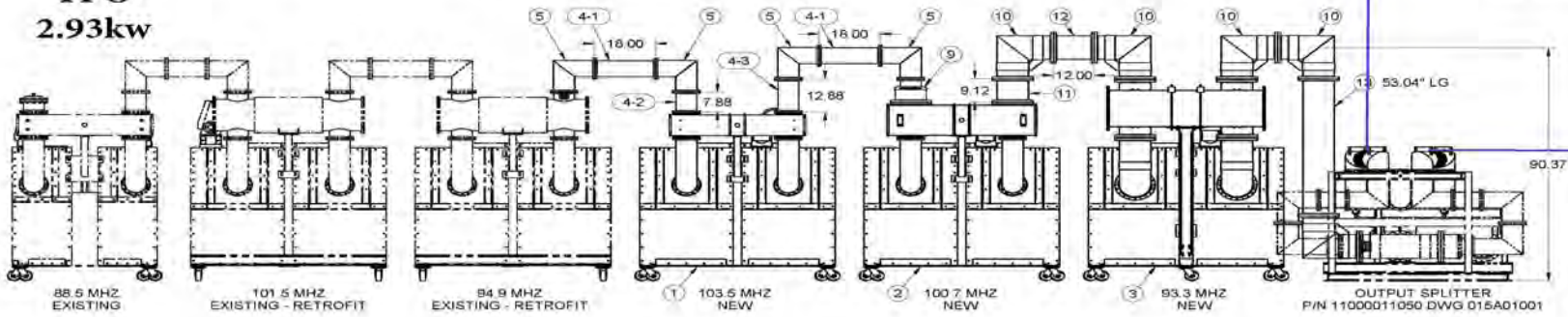
2 Ham Radio Repeaters
NI4CE Analog FM 442.550MHz
NI4CE NXDN Digital 444.4250MHz

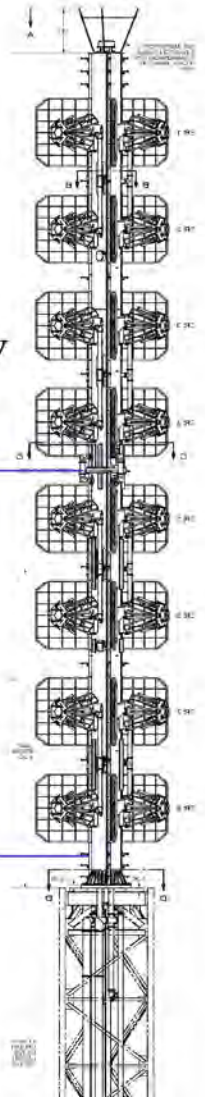
American Tower, Riverview 1
Master FM Antenna System

88.5 WMNI	HOT 101.5	magic 94.9	US FM 103.5 TAMPA BAY'S NEW COUNTRY LEADER	Mix 100.7 WMTX-FM	93.3 FLZ
88.5MHz 7kw ERP 2.65kw TPO 280w HD ERP 160 w HD TPO Total TPO 2.93kw	101.5 MHz 100kw ERP 34kw TPO 4kw HD ERP 1.4kw HD TPO Total TPO 38kw	94.9 MHz 100kw ERP 35kw TPO 4kw HD ERP 1.4kw HD TPO Total TPO 39kw	103.5 MHz 68kw ERP 22.5kw TPO HD on separate antenna Total TPO 22.5kw	100.7 MHz 100kw ERP 34kw TPO HD on separate antenna Total TPO 34kw	93.3 MHz 100kw ERP 34kw TPO HD on separate antenna Total TPO 34kw

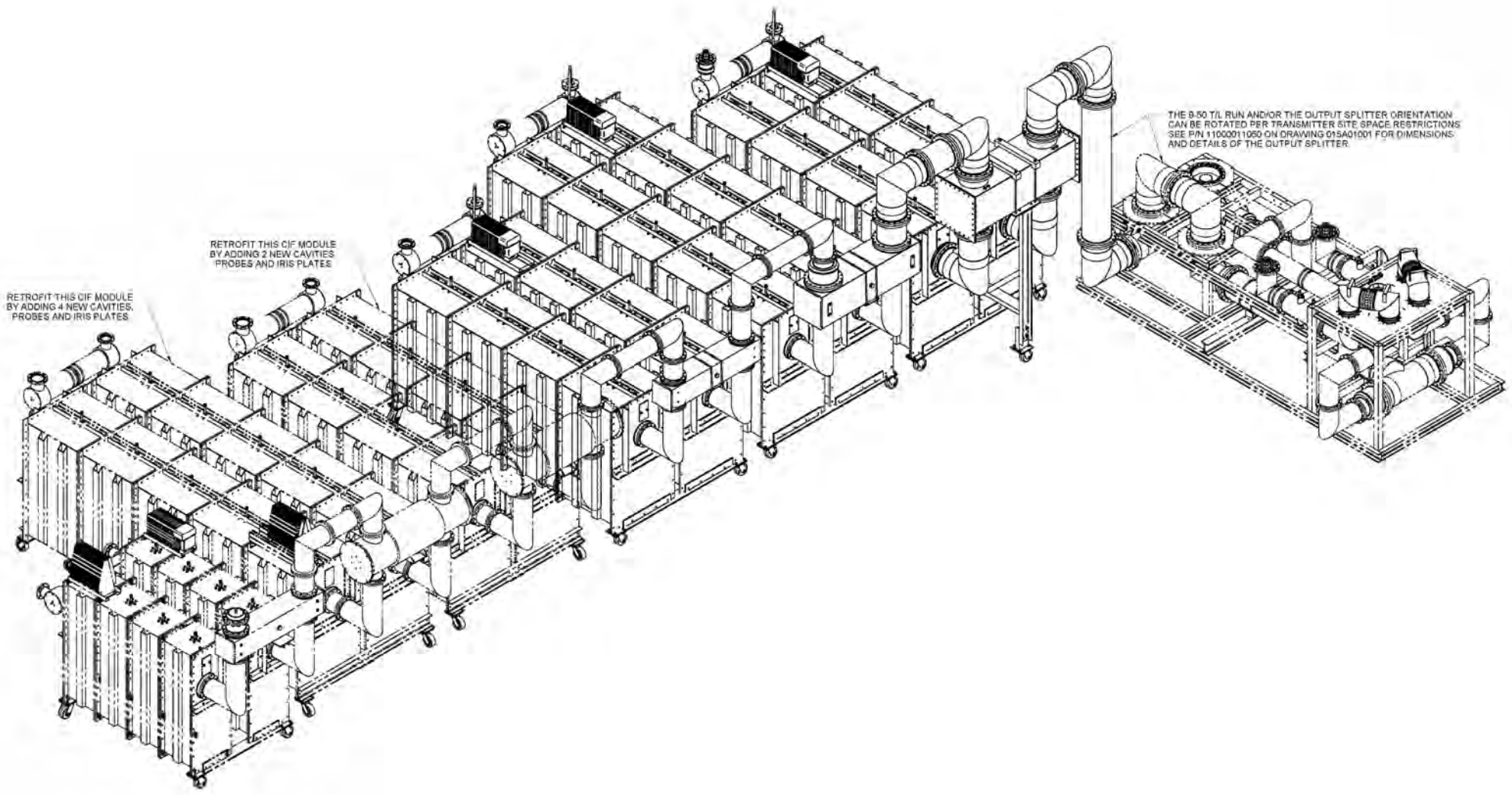
Total ERP 484kw
Total TPO 170.43kw
85.2kw per 4 bays

Two 6" Rigid Transmission lines One feeding each 4 bays

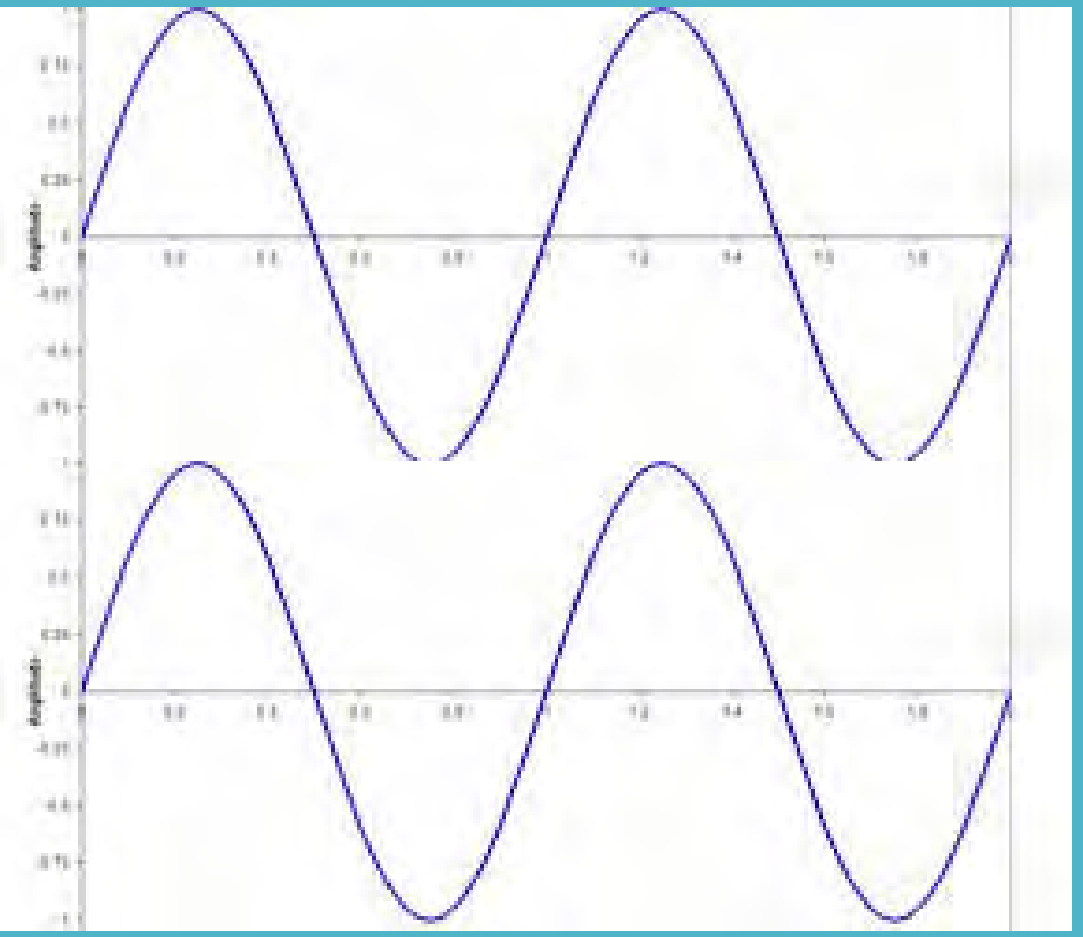




REV	SHEET	ZONE	REVISION NOTE	ECO	DRAWN / APPR.
A			PRODUCTION RELEASE		



Lets talk a little about *phasing*



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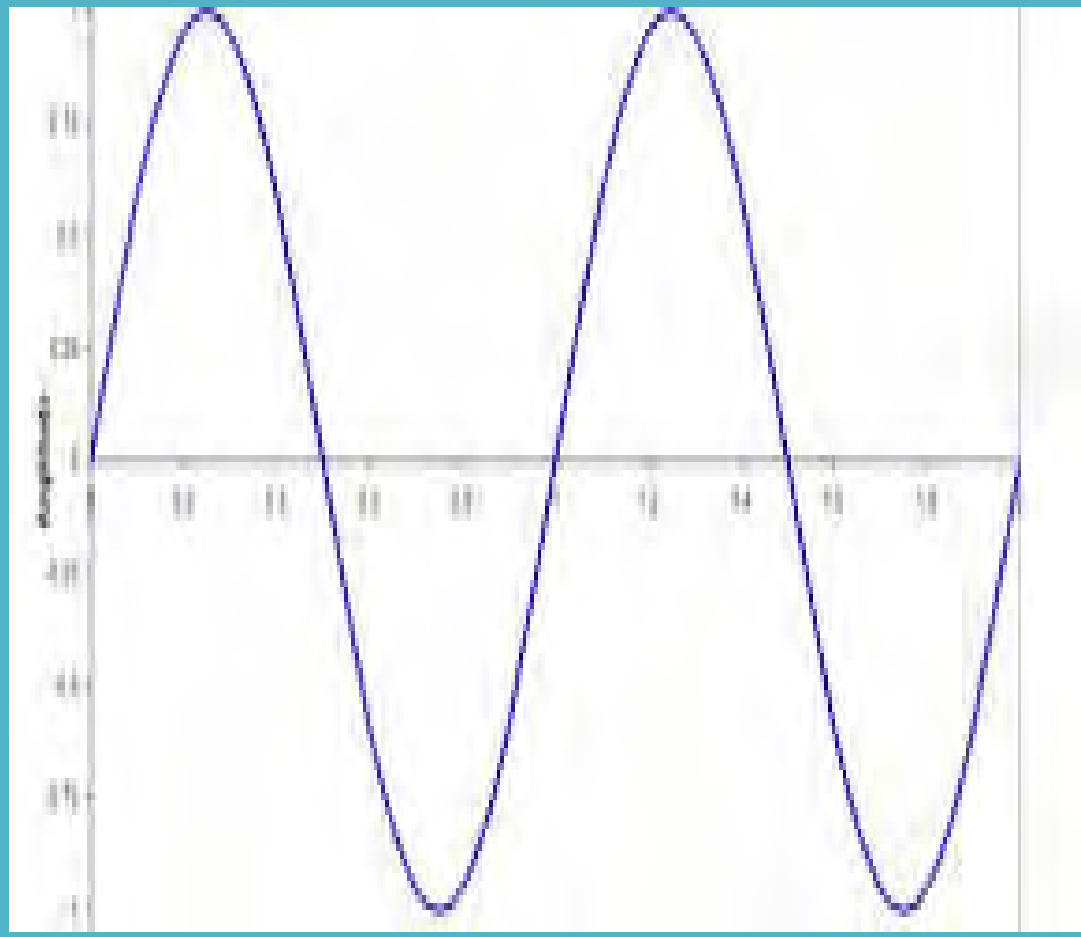
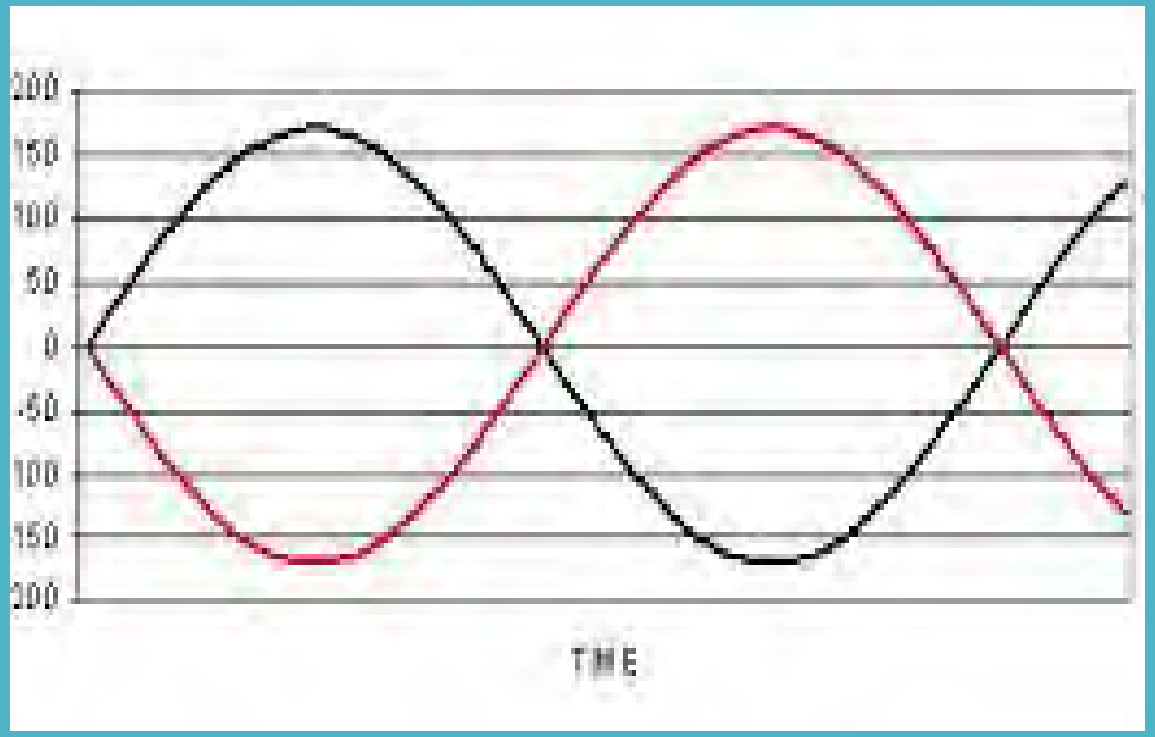


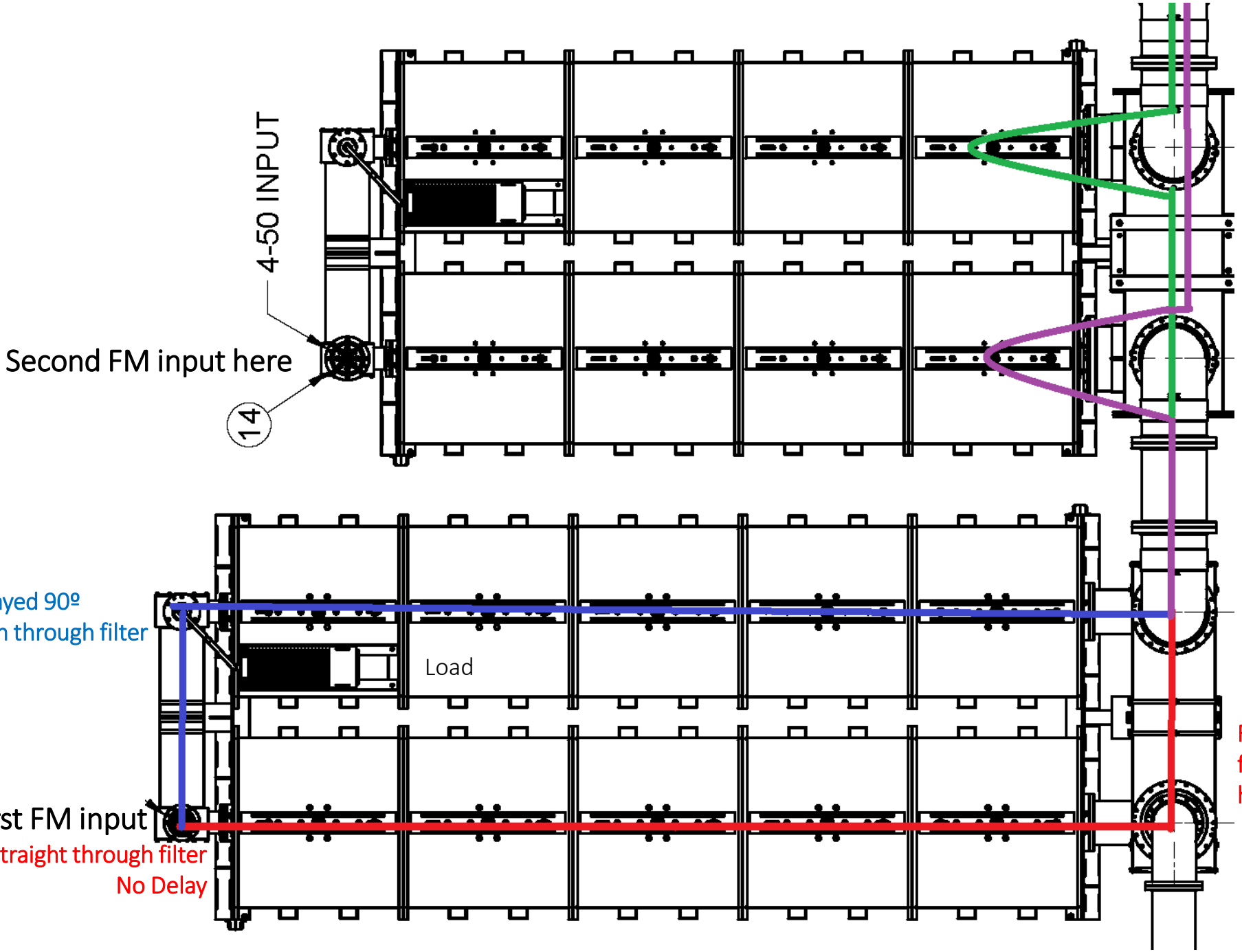
Two signals *"in-phase" combine* or add together



= No Signal

Two signals *180 degrees out of phase cancel*

Lets look at a typical set of two combiner modules



The signal from the previous combiner is split by the 3db hybrid. ½ the signal going directly to the output of the filter (purple) ½ is delayed 90º to the second filter section. Both signals are rejected by the filter and are recombined in phase at the output of the hybrid (top). Any signal appearing at the bottom of the hybrid is 180º out of phase and cancel.

1/2 signal delayed 90º by hybrid, then through filter

The Blue signal arrives at output of filter already delayed 90º. The red and blue signals now combine in phase

Red signal arrives at output of filter then is delayed 90º by hybrid

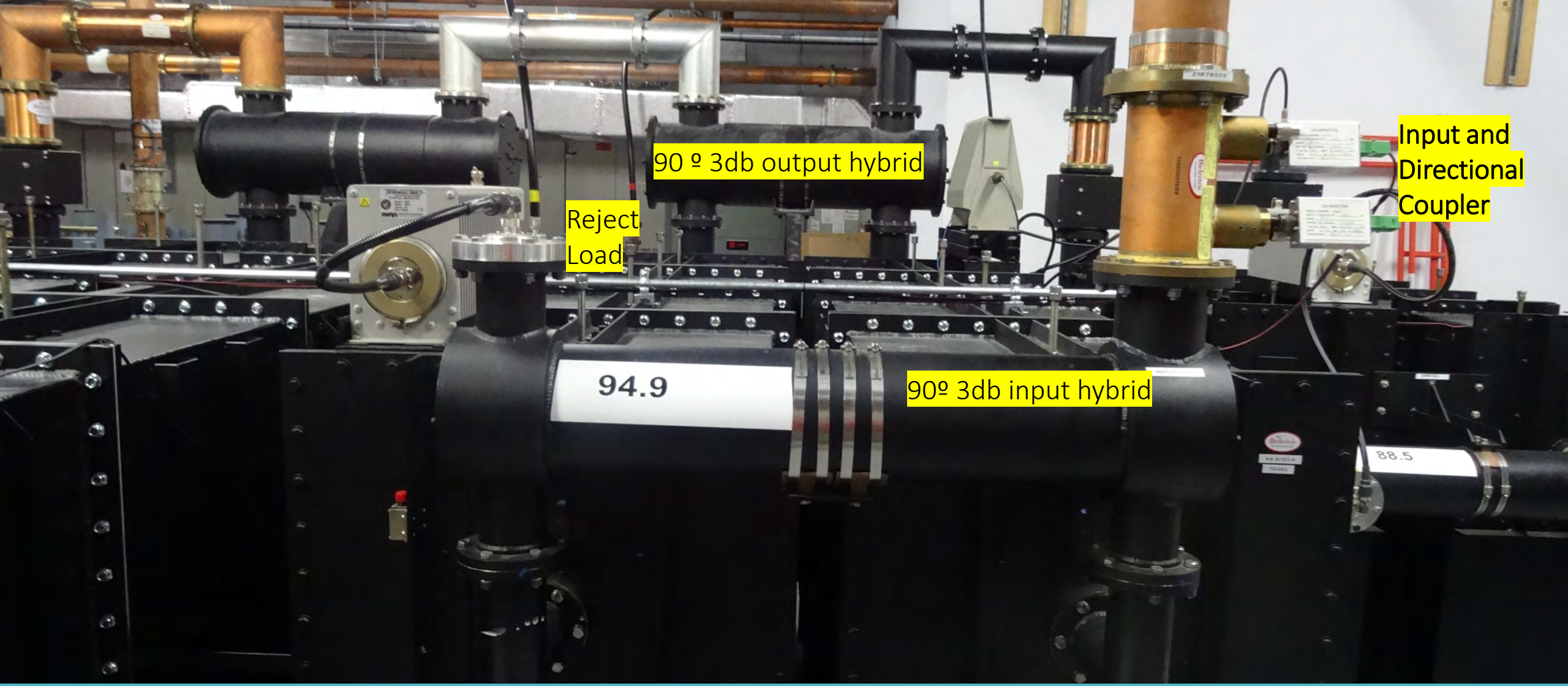
½ signal goes straight through filter No Delay

Any combined signal arriving here will be 180º out of phase and cancel

As many set of combiners modules can be added as needed for the number of stations to be combined.

Limited only by the power handling capacity of the output transmission line.

(8 3/16” 75-ohm EHT line = 397kw)



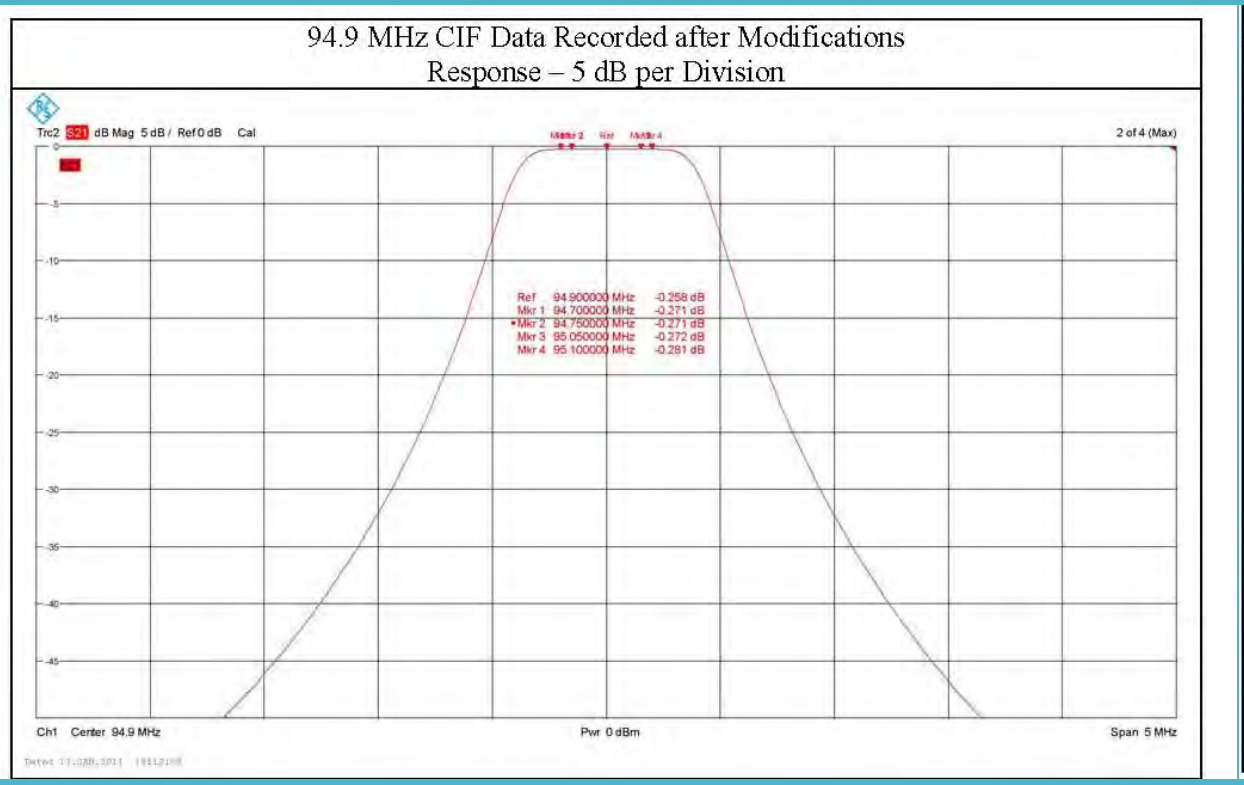
Combiner Input

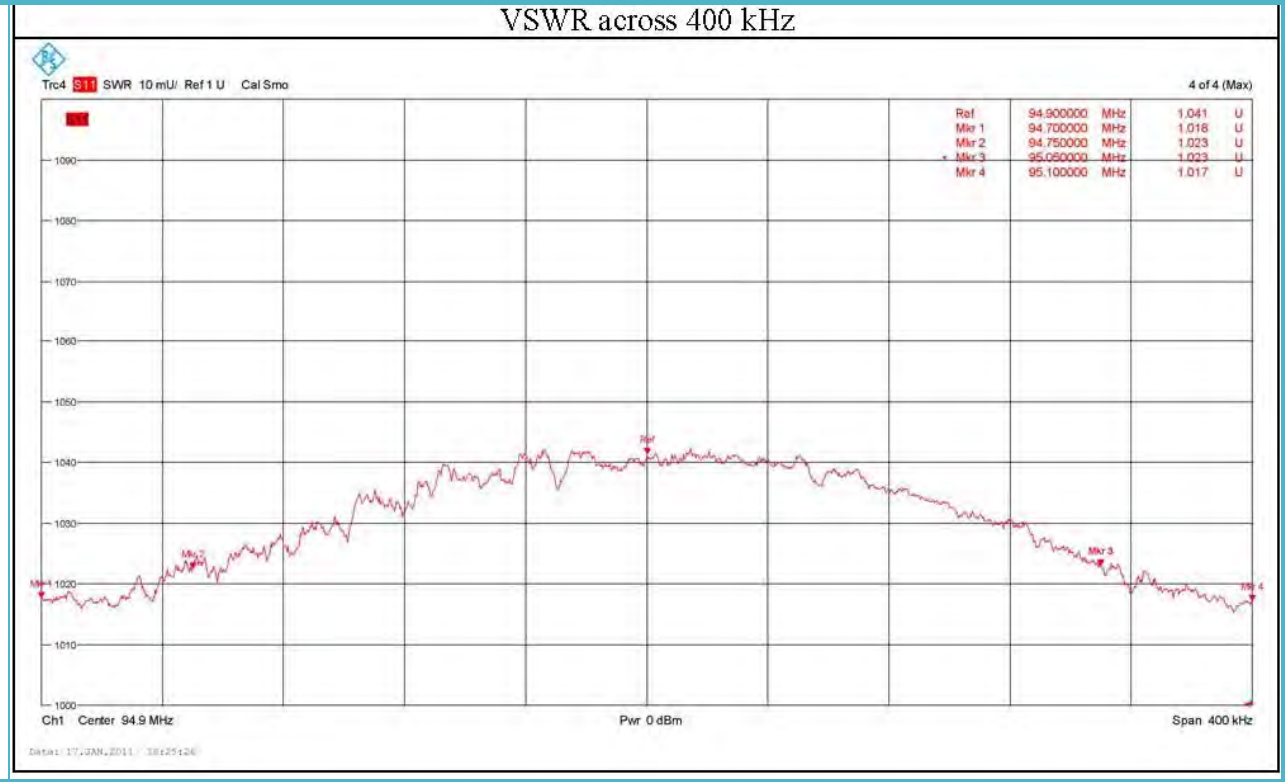
Inside the filter

Input and output coupler with
Tuning resonator

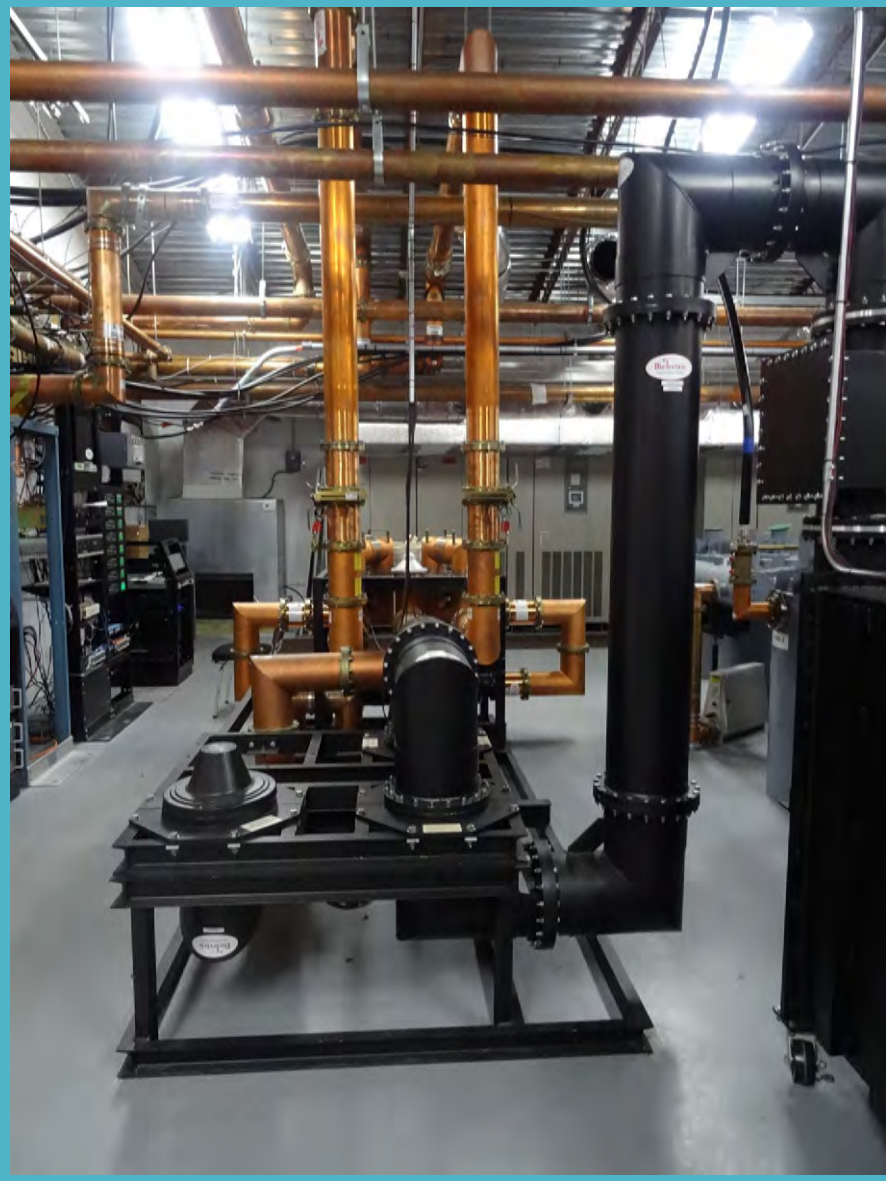
Inline filter with Tuning Resonator
and aperture to next cavity

Typical filter bandpass and VSWR





The combiner output then goes to a patch bay



Then to a 3db splitter that sends half of the power to each of the top and bottom 4-bays of the antenna

It is critical that the two transmission lines be of exactly the same length.

Here Dean Sargent measures the length of the two lines using a Vector Network Analyzer

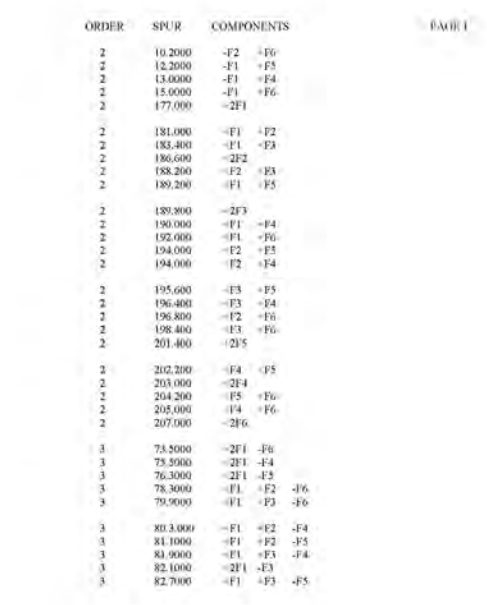
Line length Equalization Loops

Then up to the antenna

Then up to
the antenna

An Intermodulation (IM) study had to be made to make sure all FCC Spurious emission requirements were met.

It was calculated that 176 frequencies had to be measured.



ORDER	SPUR	COMPONENTS	PAGE 1
2	10.2000	-F2 +F6	
2	12.2000	-F1 +F5	
2	13.0000	-F1 +F4	
2	15.0000	-F1 +F6	
2	177.000	=2F1	
2	181.000	=F1 +F2	
2	183.400	=F1 +F3	
2	186.600	=2F2	
2	188.200	=F2 +F3	
2	189.200	=F1 +F5	
2	189.800	=2F3	
2	190.000	=F1 +F4	
2	192.000	=F1 +F6	
2	194.000	=F2 +F5	
2	194.000	=F2 +F4	
2	195.600	=F3 +F5	
2	196.400	=F3 +F4	
2	196.800	=F2 +F6	
2	198.400	=F3 +F6	
2	201.400	=2F5	
2	202.200	=F4 +F5	
2	203.000	=2F4	
2	204.200	=F5 +F6	
2	205.000	=F4 +F6	
2	207.000	=2F6	
3	73.5000	=2F1 -F6	
3	75.5000	=2F1 -F4	
3	76.3000	=2F1 -F5	
3	78.3000	=F1 +F2 -F6	
3	79.9000	=F1 +F3 -F6	
3	80.3000	=F1 +F2 -F4	
3	81.1000	=F1 +F2 -F5	
3	81.9000	=F1 +F3 -F4	
3	82.1000	=2F1 -F3	
3	82.7000	=F1 +F3 -F5	

ORDER	SPUR	COMPONENTS	PAGE 2
3	83.1000	=2F2 +F6	
3	83.7000	=2F1 -F2	
3	84.7000	=F2 +F3 -F6	
3	85.1000	=2F2 -F4	
3	85.7000	=F1 +F5 -F6	
3	85.9000	=2F2 -F5	
3	86.3000	=2F3 -F6	
3	86.5000	=F1 +F4 -F6	
3	86.7000	=F2 +F3 -F4	
3	86.9000	=F1 +F2 -F3	
3	87.5000	=F2 +F3 -F5	
3	87.7000	=F1 +F4 =F5	
3	88.3000	=2F3 -F4	
3	89.1000	=2F3 -F5	
3	89.3000	=F1 +F4 -F5	
3	90.1000	=F1 -F2 =F3	
3	90.5000	=F1 -F4 =F6	
3	90.5000	=F2 =F5 -F6	
3	91.3000	=F1 -F5 =F6	
3	91.3000	=F2 =F4 -F6	
3	91.7000	2F2 -F3	
3	92.1000	=F3 =F5 -F6	
3	92.5000	=F2 -F4 =F5	
3	92.9000	=F3 =F4 -F6	
3	94.1000	=F2 =F4 -F5	
3	94.1000	=F3 -F4 =F5	
3	94.3000	=F1 -F3 =F5	
3	95.1000	=F1 -F3 =F4	
3	95.3000	=F2 -F4 =F6	
3	95.7000	=F3 =F4 -F5	
3	95.9000	=F1 -F2 =F5	
3	96.1000	=F2 -F3 =F6	
3	96.5000	-F2 =2F3	
3	96.7000	=F1 -F2 =F4	
3	96.9000	=F3 -F4 =F6	

ORDER	SPUR	COMPONENTS	PAGE 3
3	97.1000	=F1 =F3 =F6	
3	97.7000	=F3 -F5 =F6	
3	97.9000	=2F5 -F6	
3	98.1000	-F1 =2F2	
3	98.7000	=F1 -F2 =F6	
3	98.7000	=F4 =F5 =F6	
3	99.1000	=F2 -F3 =F5	
3	99.5000	=2F4 -F6	
3	99.7000	-F1 =F2 =F3	
3	99.9000	=F2 =F3 =F4	
3	99.9000	-F4 =2F5	
3	101.300	-F1 =2F3	
3	101.900	=F2 -F3 =F6	
3	102.300	=2F4 -F5	
3	102.300	-F2 =F3 =F5	
3	102.700	-F4 =F5 =F6	
3	103.100	-F2 =F3 =F4	
3	104.300	=F4 =F5 =F6	
3	105.100	-F2 =F3 =F6	
3	105.500	-F4 =2F6	
3	105.500	-F1 =F2 =F5	
3	106.300	-F5 =2F6	
3	106.300	-F1 =F2 =F4	
3	106.500	-F3 =2F5	
3	107.100	-F1 =F3 =F5	
3	107.300	-F3 =F4 =F5	
3	107.900	-F1 =F3 =F4	
3	108.100	-F3 =2F4	
3	108.100	-F2 =2F5	
3	108.300	-F1 =F2 =F6	
3	108.900	-F2 =F4 =F5	
3	109.300	-F3 =F5 =F6	
3	109.700	-F2 =2F4	
3	109.900	-F1 =F3 =F6	
3	110.100	-F3 =F4 =F6	

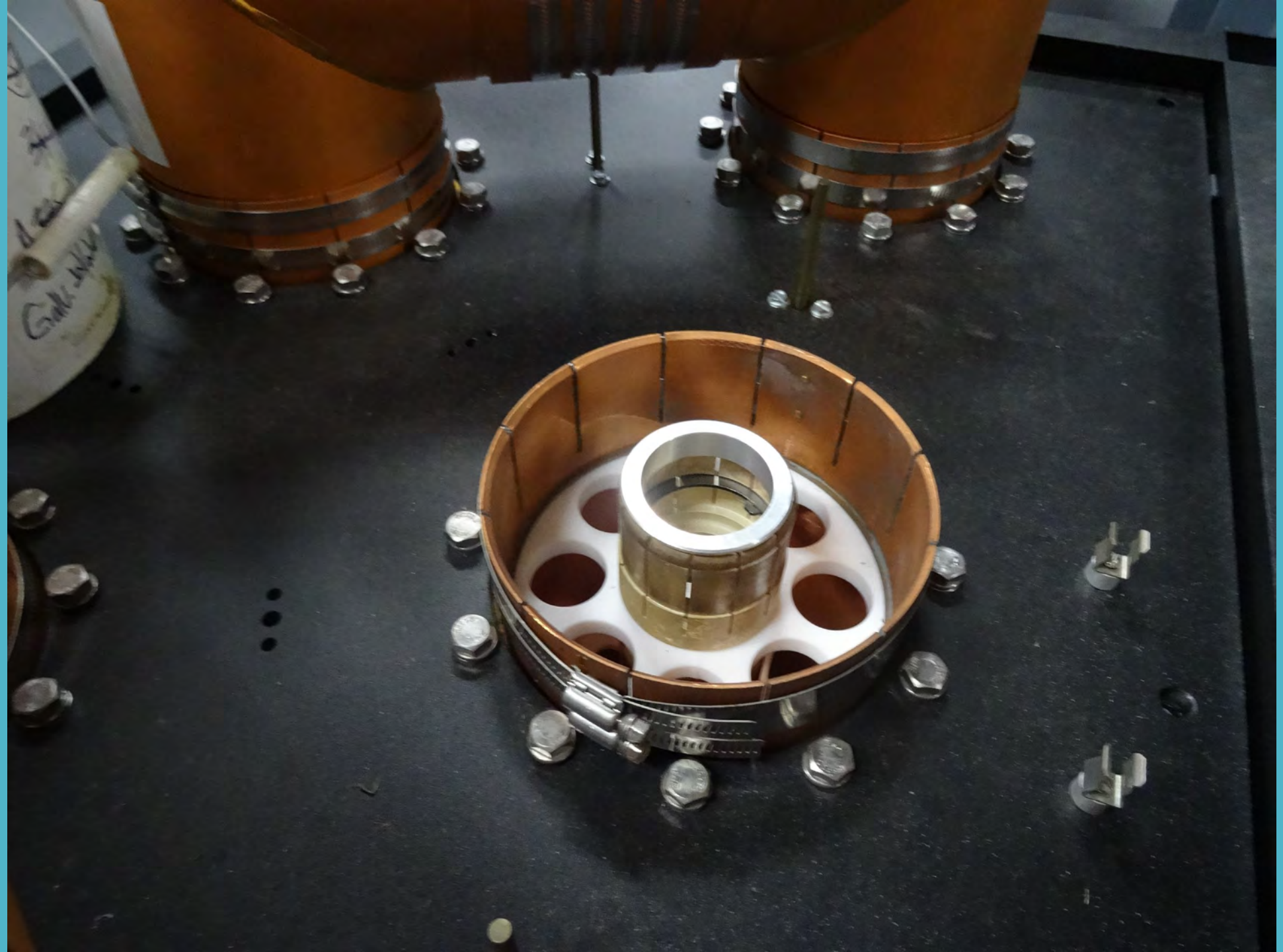
ORDER	SPUR	COMPONENTS	PAGE 4
3	110.900	-F2 =F5 =F6	
3	111.700	-F2 =F4 =F6	
3	112.100	-F3 =2F6	
3	112.900	-F1 =2F5	
3	113.700	-F2 =2F6	
3	113.700	-F1 =F4	
3	114.500	-F1 =2F4	
3	115.700	-F1 =F5 =F6	
3	116.500	-F3 =F4 =F6	
3	118.500	-F1 =2F6	
3	265.500	3F1	
3	270.300	=2F1 =F2	
3	271.900	=2F1 =F3	
3	275.100	=F1 =2F2	
3	276.700	=F1 =F2 =F3	
3	277.700	=2F1 =F5	
3	278.300	=F1 =2F3	
3	278.500	=2F1 =F4	
3	279.900	=3F2	
3	280.500	=2F1 =F6	
3	281.500	=2F2 =F3	
3	282.500	=F1 =F3	
3	283.100	=F2 =F3	
3	283.300	=F1 =F2 =F4	
3	284.100	=F1 =F3 =F5	
3	284.700	=3F3	
3	284.900	=F1 =F3 =F4	
3	285.300	=F1 =F2 =F6	
3	286.900	=F1 =F3 =F6	
3	287.300	=2F2 =F5	
3	288.100	=2F2 =F4	
3	288.900	=F2 =F3 =F5	
3	289.700	=F2 =F3 =F4	
3	289.900	=F1 =2F5	
3	290.100	=2F2 =F6	

ORDER	SPUR	COMPONENTS	PAGE 5
3	290.500	=2F3 =F5	
3	290.700	=F1 =F4 =F5	
3	291.300	=2F3 =F4	
3	291.500	=F1 =2F4	
3	291.700	=F2 =F3 =F6	
3	292.700	=F1 =F5 =F6	
3	293.300	=2F3 =F6	
3	293.500	=F1 =F4 =F6	
3	294.700	=F2 =2F5	
3	295.500	=F1 =2F6	
3	295.500	=F2 =F4 =F5	
3	296.300	=F2 =2F4	
3	296.300	=F3 =2F5	
3	297.100	=F3 =F4 =F5	
3	297.500	=F2 =F5 =F6	
3	297.900	=F3 =2F4	
3	298.300	=F2 =F4 =F6	
3	299.100	=F3 =F5 =F6	
3	299.900	=F3 =F4 =F6	
3	300.300	=F2 =2F6	
3	301.900	=F3 =2F6	
3	302.100	=3F5	
3	302.900	=F4 =2F5	
3	303.700	=2F4 =F5	
3	304.500	=3F4	
3	304.900	=2F5 =F6	
3	305.700	=F4 =F5 =F6	
3	306.500	=2F4 =F6	
3	307.700	=F5 =2F6	
3	308.500	=F4 =2F6	
3	310.500	3F6	

The fundamental frequencies were notched out using tunable filters and the resultant signal was read on a Spectrum Analyzer.
FCC Rules require all Spurious Emissions be <-80dbc. No emissions were found exceeding this level.

IM Product Frequency MHz	Attenuator dB	Filter Loss dB	Directional Coupler Correction dB	IM Product Level dBm	IM Product Corrected Level dBm	Carrier Reference Level dBm	IM Product Level Reference To Carrier Level dB
86.7	10	0	19.1	-64.43	-73.53	10.77	-84.3
87.5	10	0	19.1	-65.59	-74.69	10.77	-85.46
90.5	10	0	19.1	-66.31	-75.41	10.77	-86.18
91.3	10	0	19.1	-66.99	-76.09	10.77	-86.86
92.1	10	0	19.1	-66.59	-75.69	10.77	-86.46
92.5	10	0	19.1	-63.62	-72.72	10.77	-83.49
98.7	10	0	19.1	-64.05	-73.15	10.77	-83.92
99.1	10	0	20	-62.43	-72.43	10.77	-83.2
99.9	10	0	20	-62.29	-72.29	10.77	-83.06
107.3	10	0	24	-64.1	-78.1	10.77	-88.87
108.9	10	0	24	-66.22	-80.22	10.77	-90.99
109.3	10	0	24	-67.28	-81.28	10.77	-92.05
					0		0


Antenn
Lower h
Ante
Uppe
NOT AN EXIT
NOT AN EXIT
OUTPUT
Dielectric




RF Scout XLT
RF Scout XLT
RF Scout XLT
RF Scout XLT
Lower


No Smoking


EXIT

Questions?