SO, WHAT HAVE WE LEARNED OR WHAT TO DO ABOUT IBOC

IBOC Review

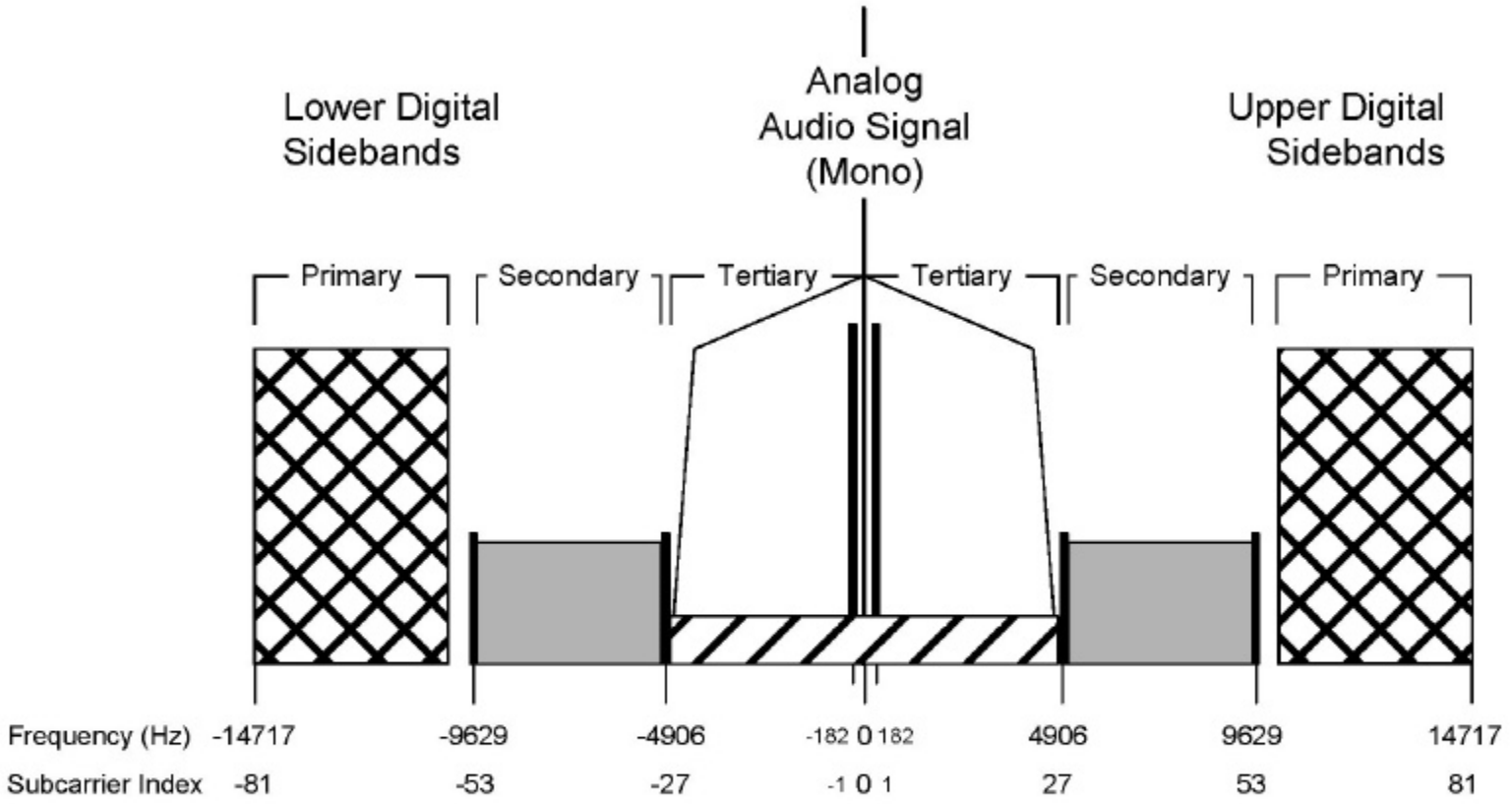


Figure 2 AM IBOC hybrid waveform spectrum.

Antenna Performance Concerns

- Unnecessarily High Digital-to-Analog Crosstalk (Hiss and “Bacon Frying” Sound)
- Decreased “Robustness” of Digital Signal
- Digital Coverage Area Limited by Pattern Bandwidth
- Higher Adjacent Channel Interference Resulting from Poor Pattern Bandwidth
- Noisier Analog Reception in DA Null Region Due to Poor Pattern Bandwidth

IBOC Antenna System Requirements (as we know now)

- +/- 5 kHz – RF Final Amplifier Load Impedance Symmetry Such That VSWR of One Sideband Impedance Does Not Exceed 1.035:1 When Normalized to the Complex Conjugate of the Corresponding Sideband Impedance on the Other Side of Carrier Frequency (Hermitian Symmetry)
- +/- 10 kHz – RF Final Amplifier Load Impedance VSWR Not Exceeding 1.20:1
- +/- 15 kHz – RF Final Amplifier Load Impedance VSWR Not Exceeding 1.40:1

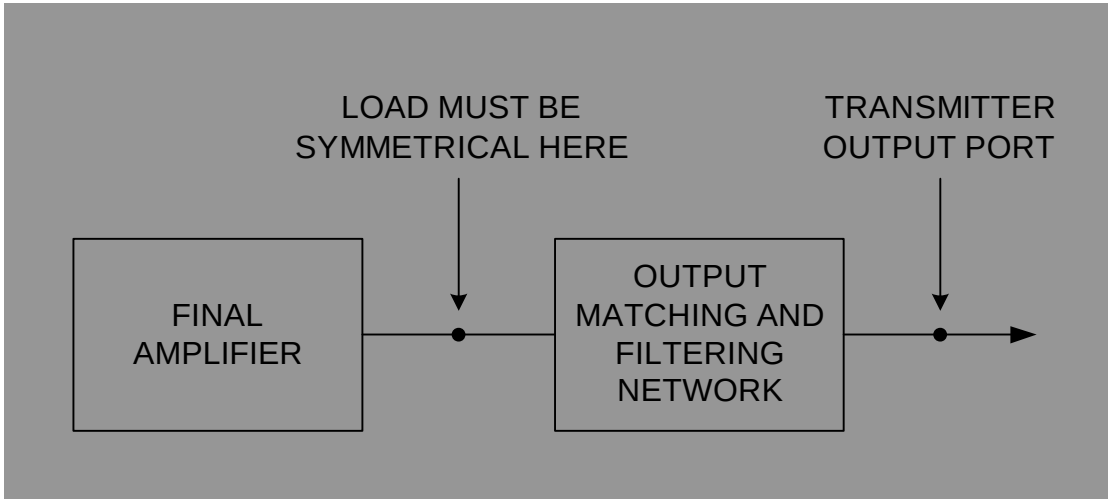
IBOC Antenna System Requirements (as we know now) Cont.

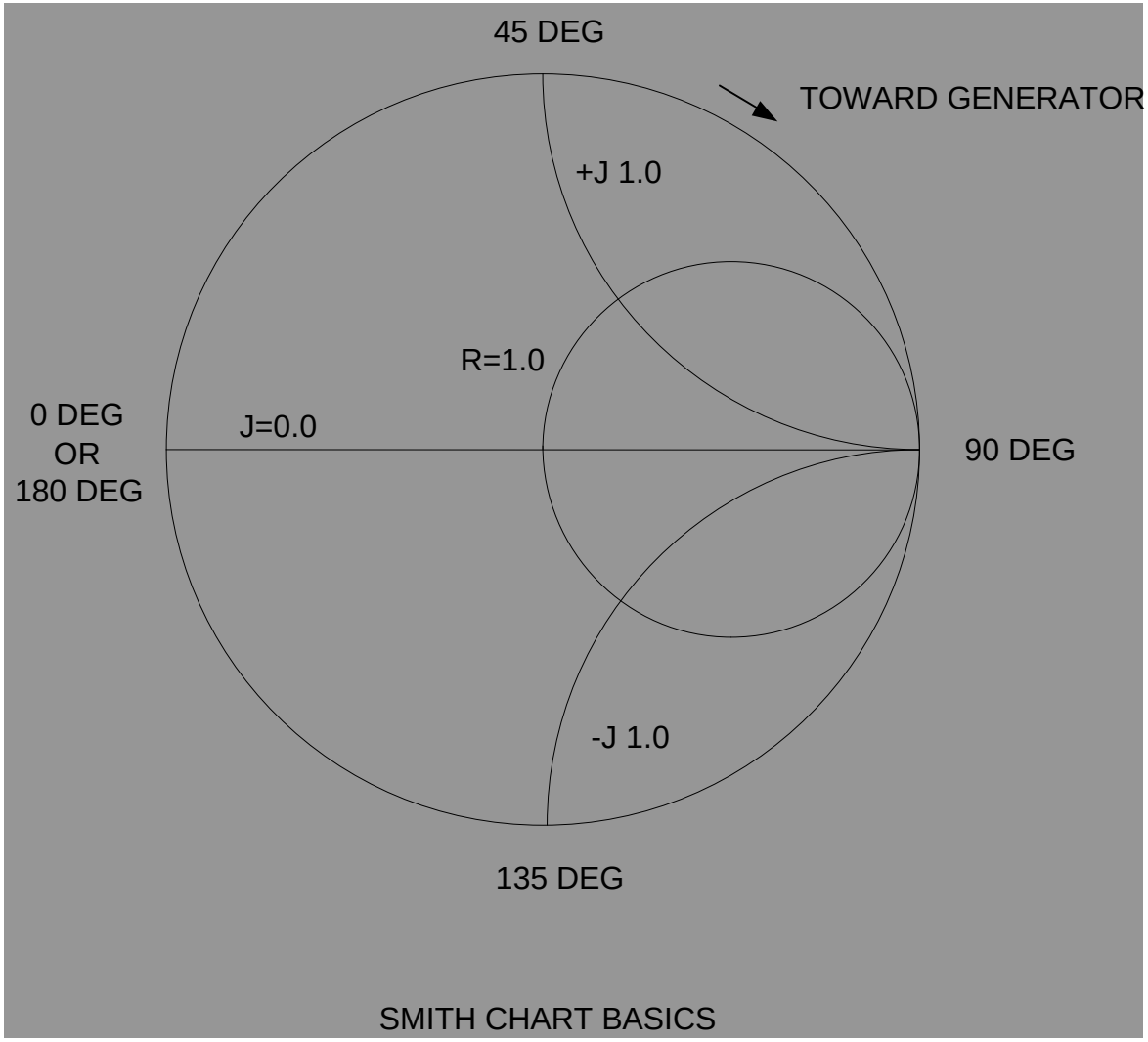
- For Directional Antennas
  - Amplitude Response of +/- 2 dB across the 30 kHz Bandwidth
  - Phase Response of less than 27º across the 30 kHz of Bandwidth

Optimizing Load Impedance

- Reduces Noise from Digital-To-Analog Crosstalk
- Improves Spectral Purity of Digital Signal
- Improves Headroom for Receiver Error Correction

Final Amplifier Load Optimization





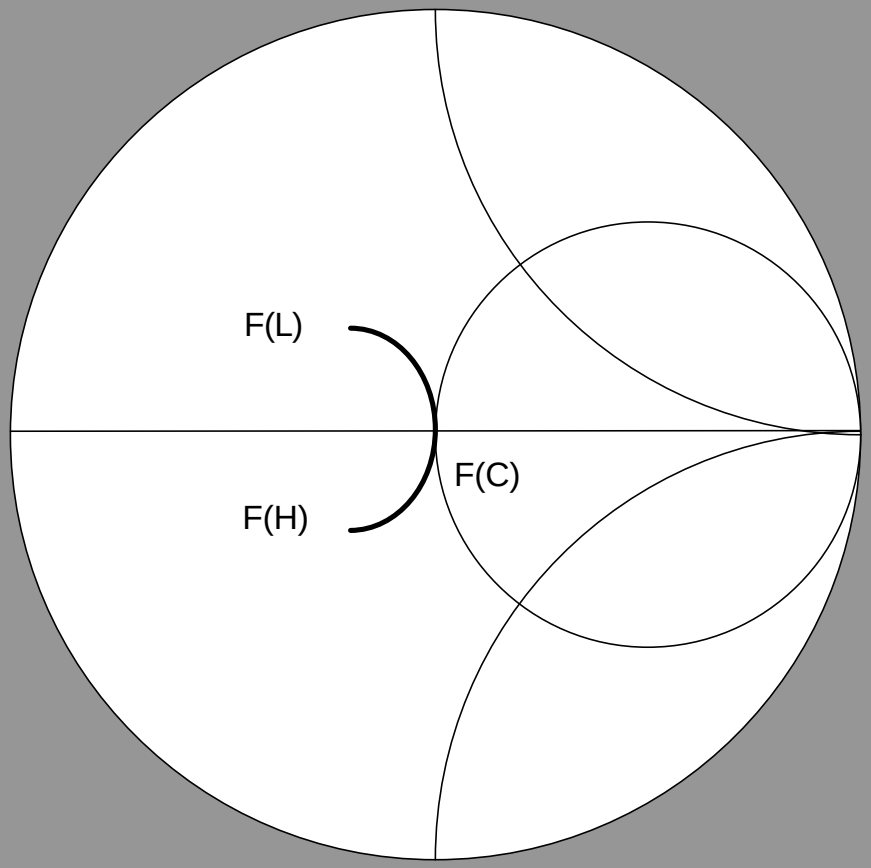
SMITH CHART BASICS

Normalizing Per-Unit Values of Impedance

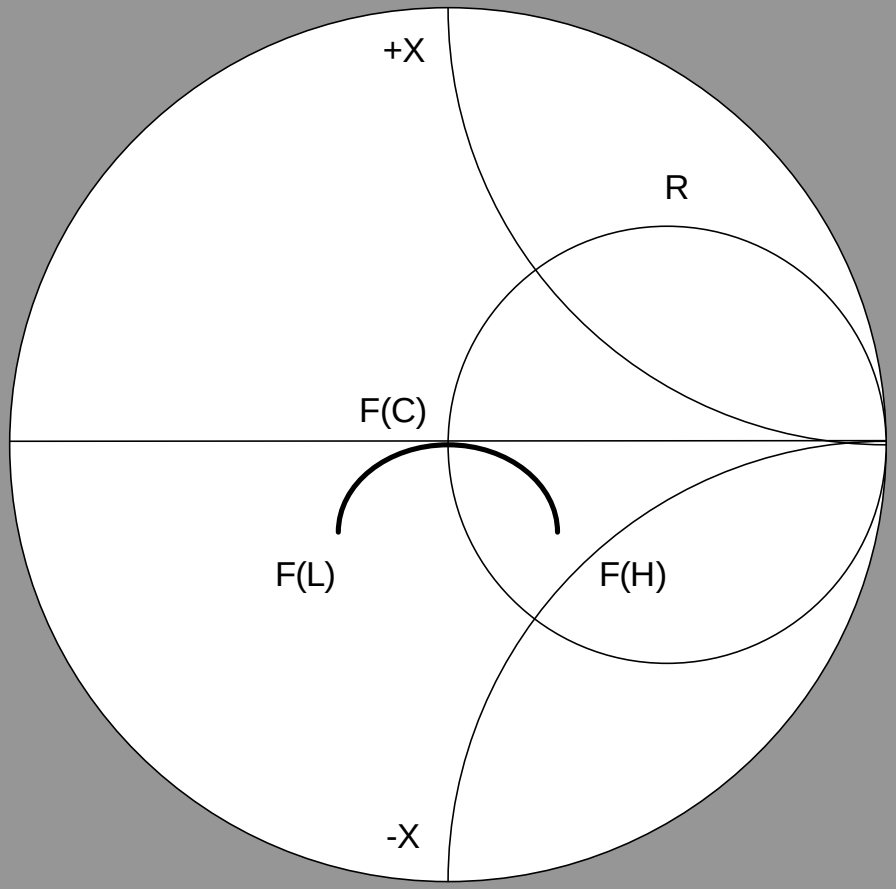
- Divide Each Sideband Resistance by the Carrier Resistance
- Divide the Difference Between Each Sideband Reactance and the Carrier Reactance by the Carrier Resistance

Normalizing Examples

Frequency	Resistance	Reactance	Per-Unit Resistance	Per-Unit Reactance
-15 kHz	45.0	-j 8.0	0.90	-j 0.16
Carrier	50.0	j 0.0	1.00	j 0.00
+15 kHz	57.0	+j 10.0	1.14	+j 0.20
-15 kHz	45.0	-j 8.0	0.86	-j 0.09
Carrier	52.5	-j 3.5	1.00	j 0.00
+15 kHz	57.0	+j 10.0	1.09	+j 0.12

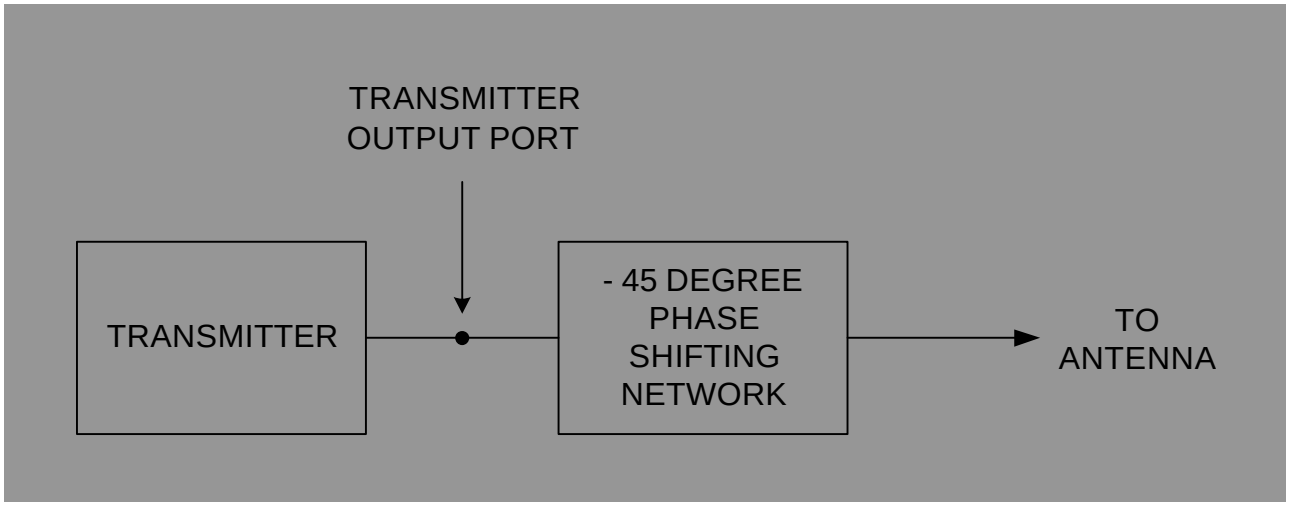


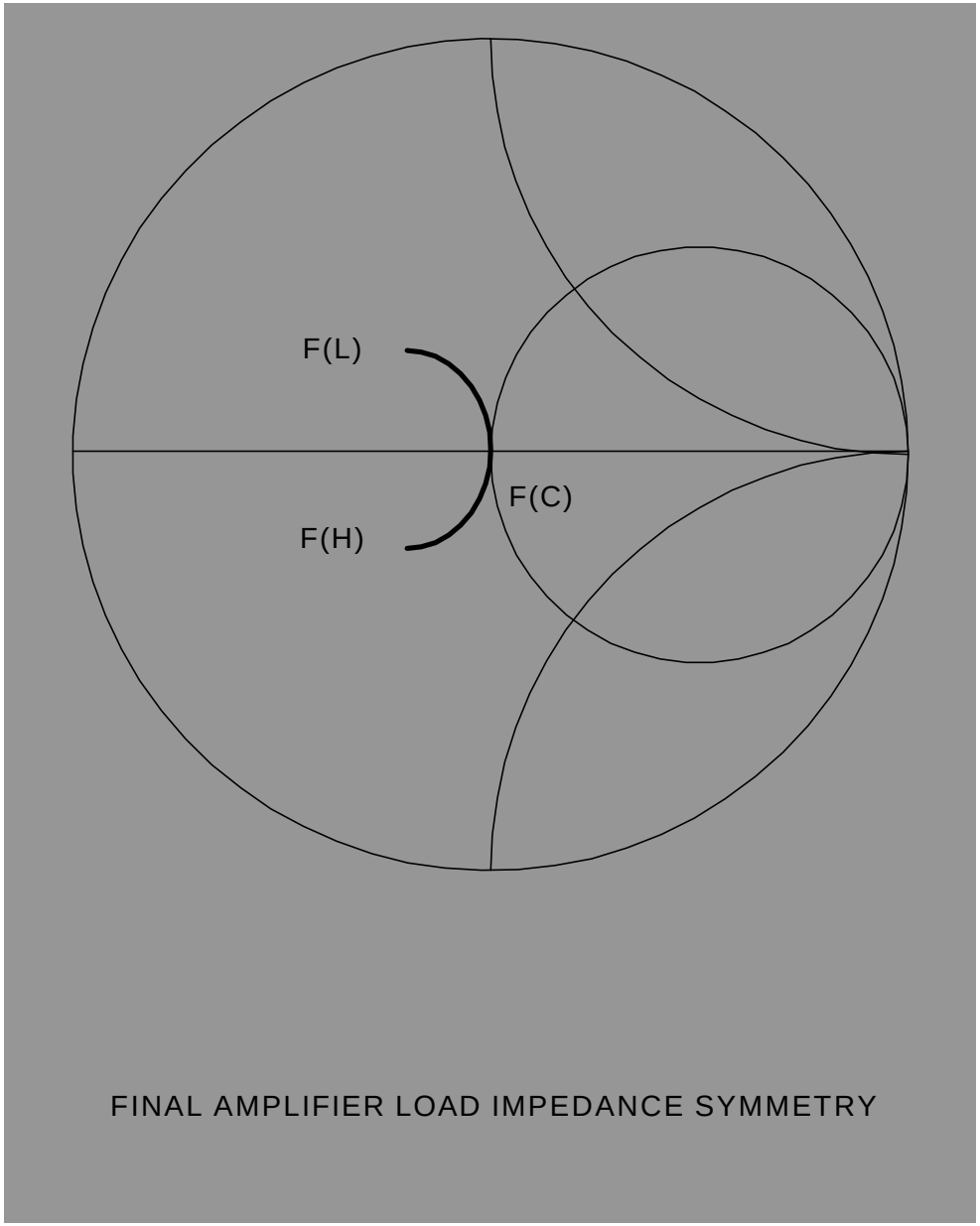
FINAL AMPLIFIER LOAD IMPEDANCE SYMMETRY



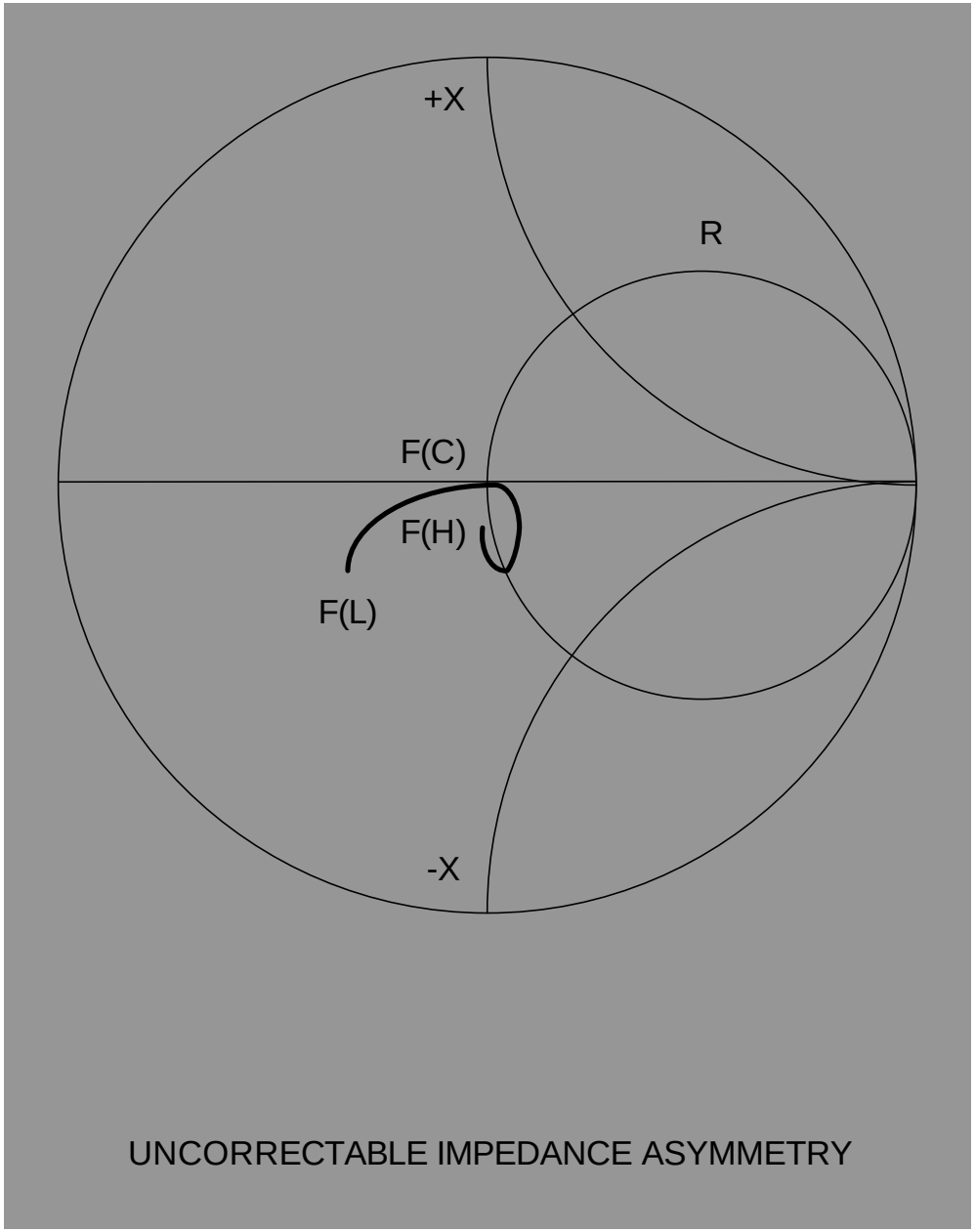
FINAL AMPLIFIER
LOAD IMPEDANCE ASSYMMETRY

Phase Rotation Network



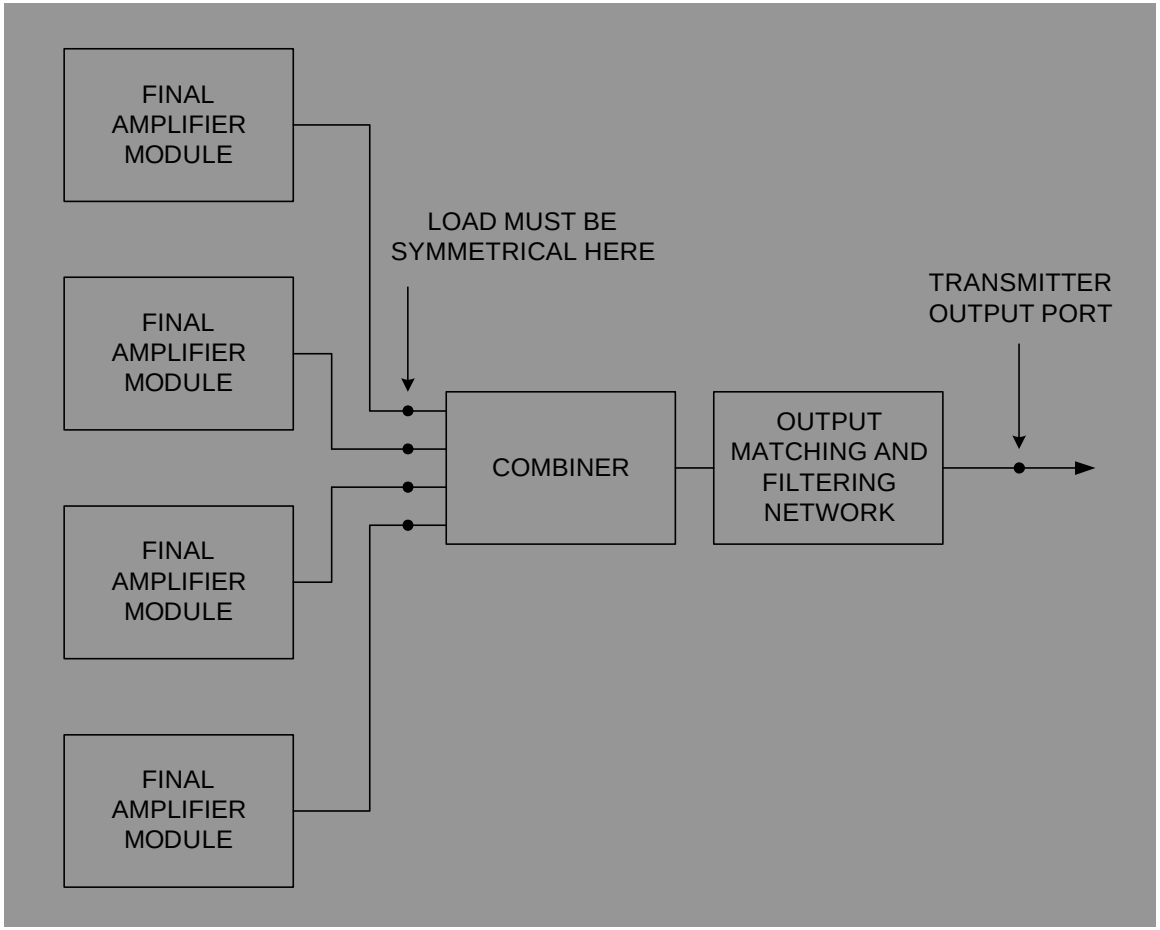


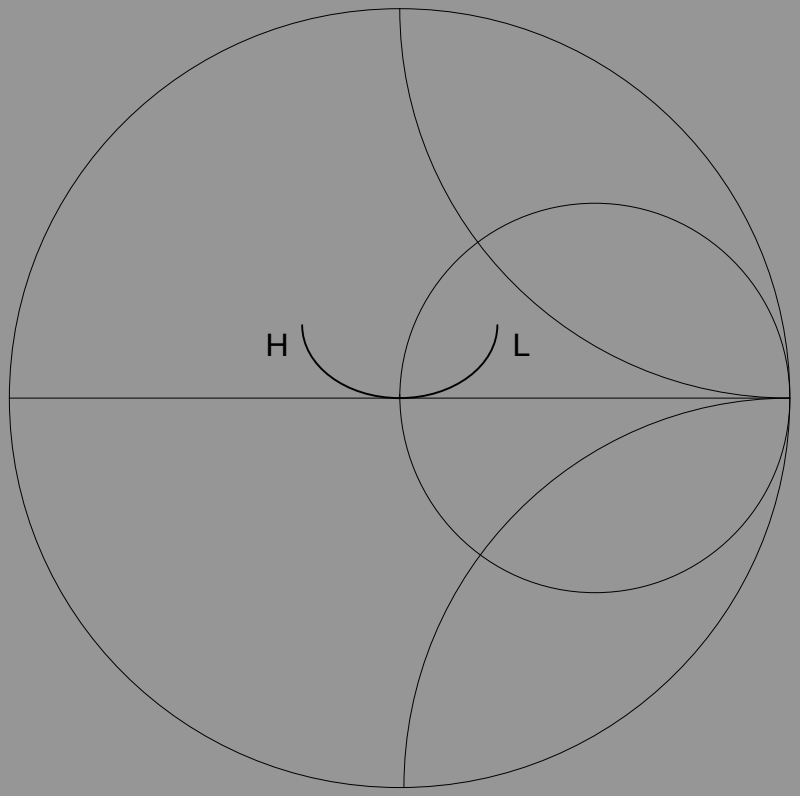
FINAL AMPLIFIER LOAD IMPEDANCE SYMMETRY



UNCORRECTABLE IMPEDANCE ASYMMETRY

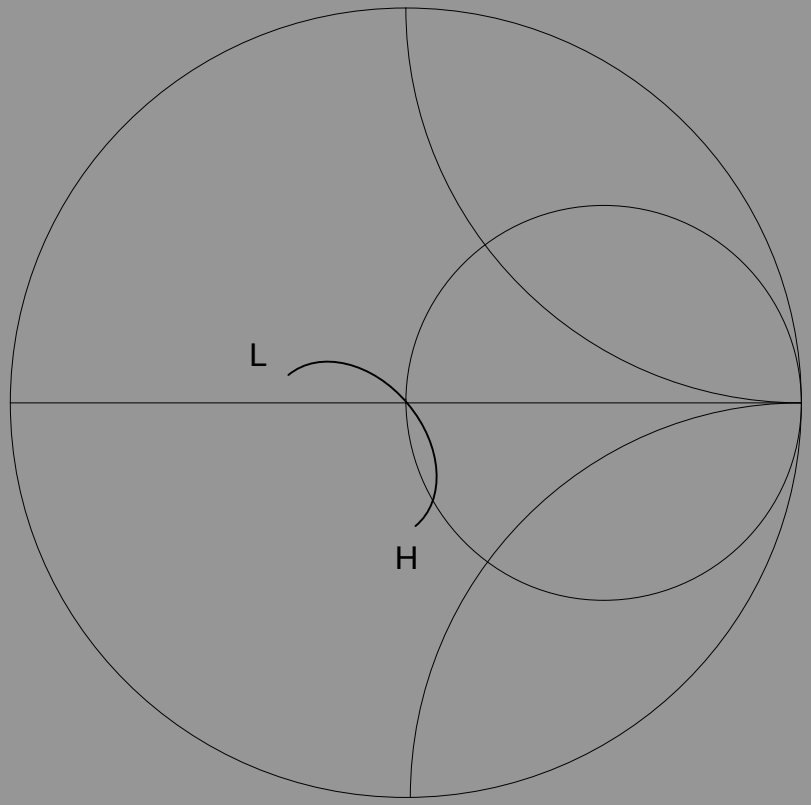
Transmitters With Transformer Combiners





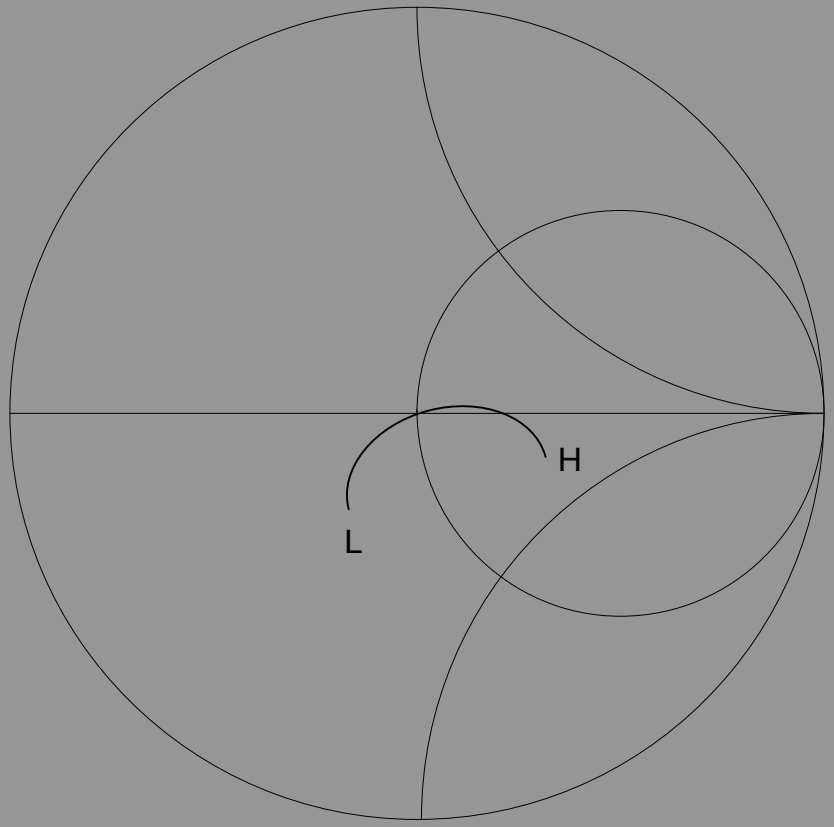
SYMMETRICAL SIDEBAND LOAD
FOR TRANSMITTER WITH
-135 DEGREE OUTPUT NETWORK

(MOST HARRIS MODELS)



SYMMETRICAL SIDEBAND LOAD
FOR TRANSMITTER WITH
-200 DEGREE OUTPUT NETWORK

(MOST BE MODELS)

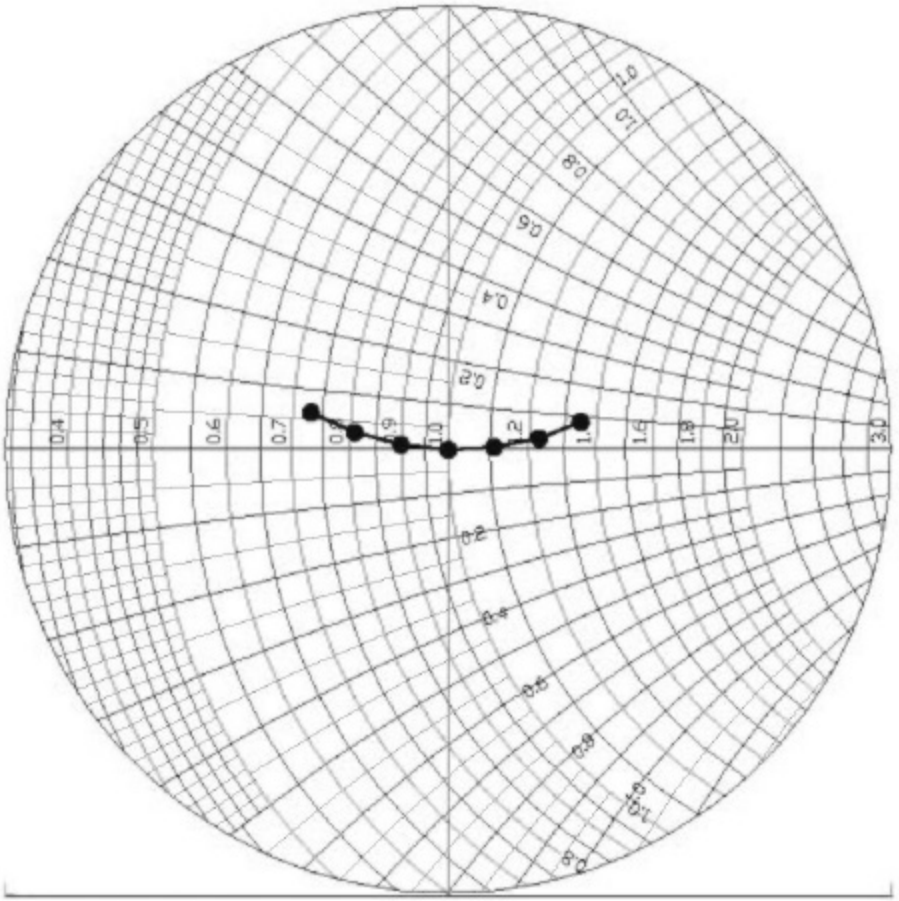


SYMMETRICAL SIDEBAND LOAD
FOR TRANSMITTER WITH
-60 DEGREE OUTPUT NETWORK

(NAUTEL MODELS?)

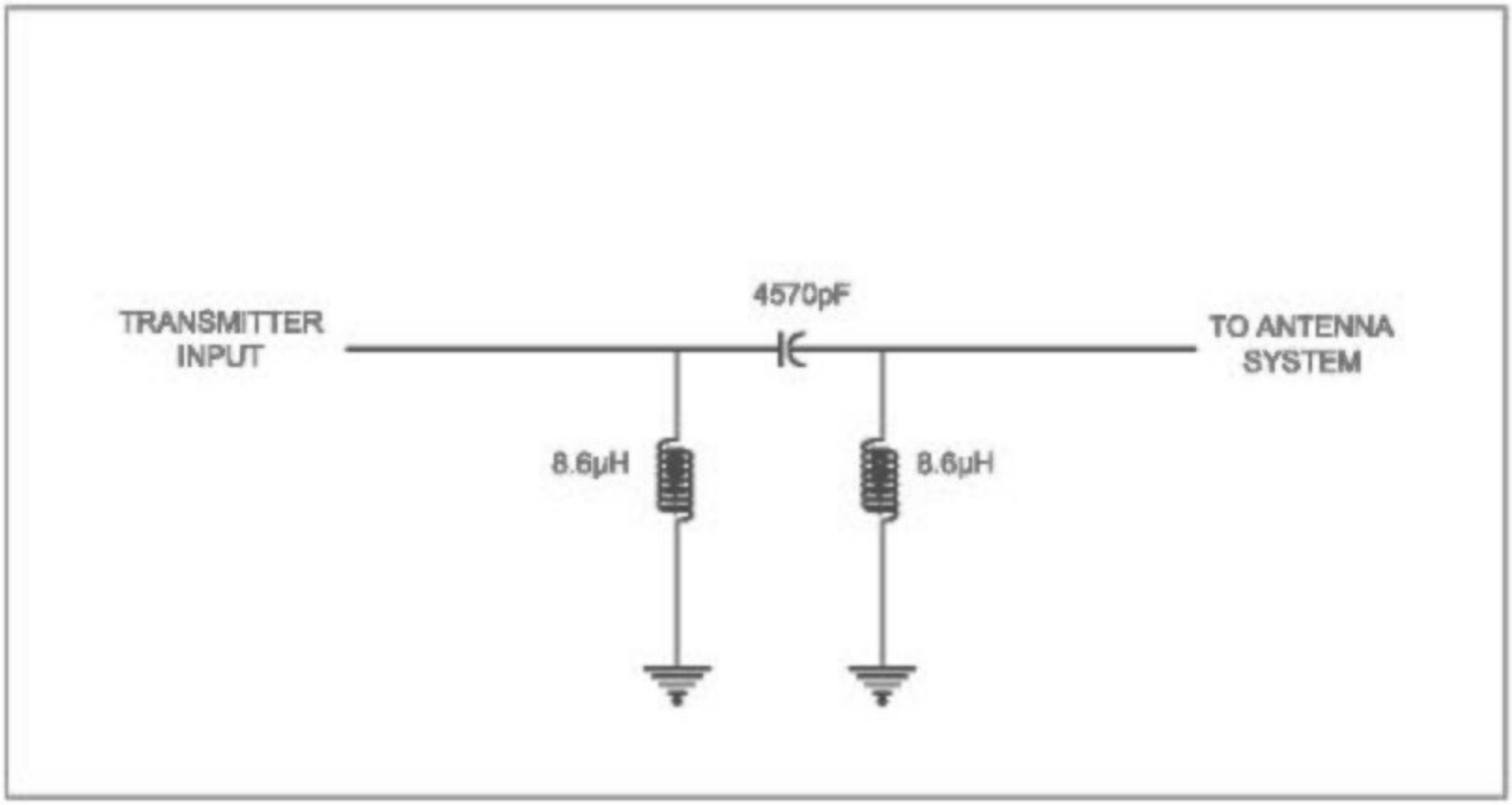
KOTZ

Frequency (kHz)	Impedance Resistance	Reactance	VSWR	IBOC VSWR	IBOC Symmetry	VSWR
705	67.5	4.4	1.363	Yes		
710	61.4	1.6	1.231	No		
715	55.5	0.4	1.110	Yes		
720	50.0	0.0	1.000		No	1.235
725	45.0	0.6	1.112	Yes		
730	40.4	1.7	1.241	No		
735	36.5	3.2	1.381	Yes		

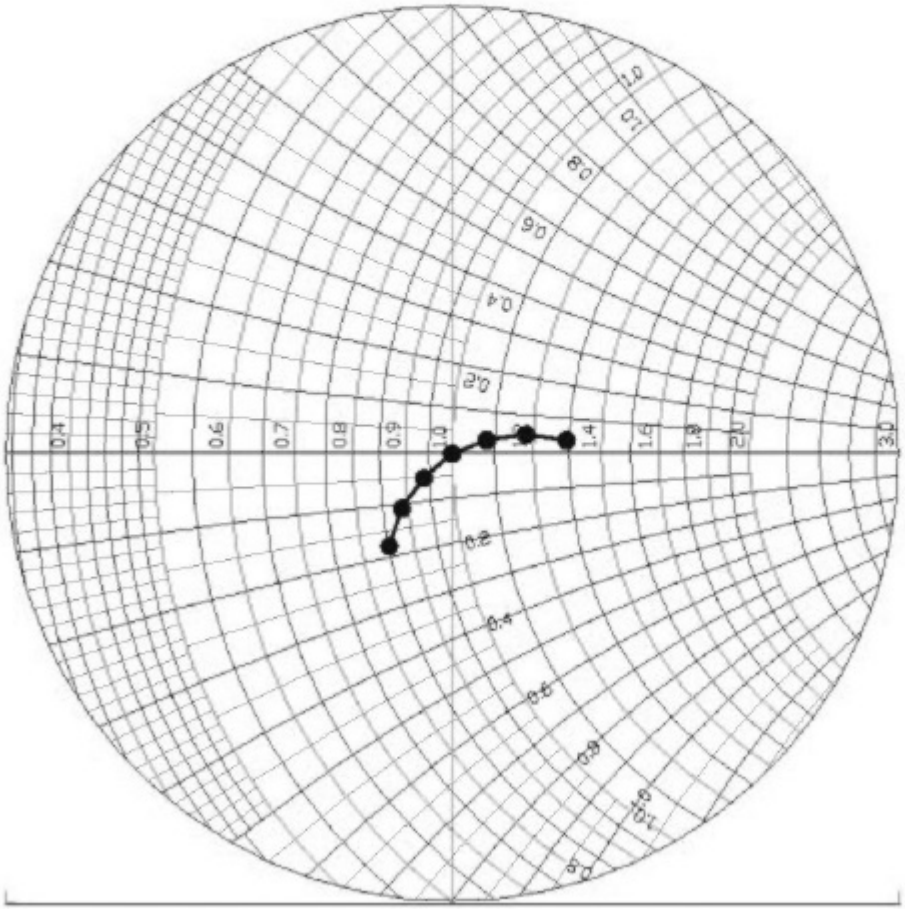


Load At Antenna Feed Line

104.5º Rotation

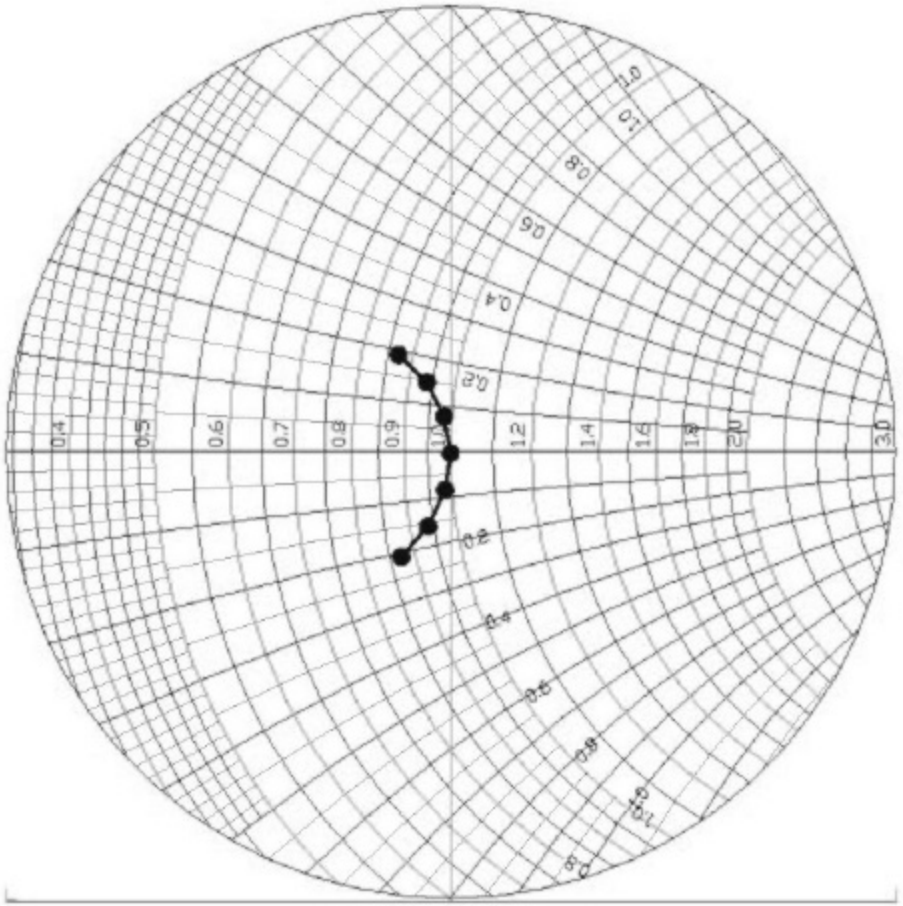


Frequency (kHz)	Impedance Resistance	Reactance	VSWR	IBOC VSWR	IBOC Symmetry	VSWR
705	42.6	-8.9	1.285	Yes		
710	44.3	-5.4	1.181	Yes		
715	46.8	-2.5	1.087	Yes		
720	50.0	0.0	1.000		No	1.155
725	54.0	1.7	1.088	Yes		
730	59.0	2.6	1.188	Yes		
735	64.6	2.0	1.296	Yes		



Load Rotated Through Phase Rotation Network

Frequency (kHz)	Impedance Resistance	Reactance	VSWR	IBOC VSWR	IBOC Symmetry	VSWR
705	43.5	9.7	1.285	Yes		
710	46.8	7.4	1.181	Yes		
715	49.1	4.0	1.087	Yes		
720	50.0	-0.0	1.000		Yes	1.003
725	49.2	-4.1	1.088	Yes		
730	46.9	-7.8	1.188	Yes		
735	43.6	-10.3	1.296	Yes		



Load Rotated in Transmitter Ouput Network

Where to Go From Here

- Transmitter Manufactures are Thinking About This Problem – Adaptive Equalization
- Not Pass-Fail Test – IBOC Signal Has Redundancy
- See What Happens
- Alaska Need to Propose a State Wide STA to Use IBOC For Daytime and Nighttime

E-Mail or Call Me

Stephen S. Lockwood, P.E.

(206) 783-9151

Lockwood@hatdaw.com