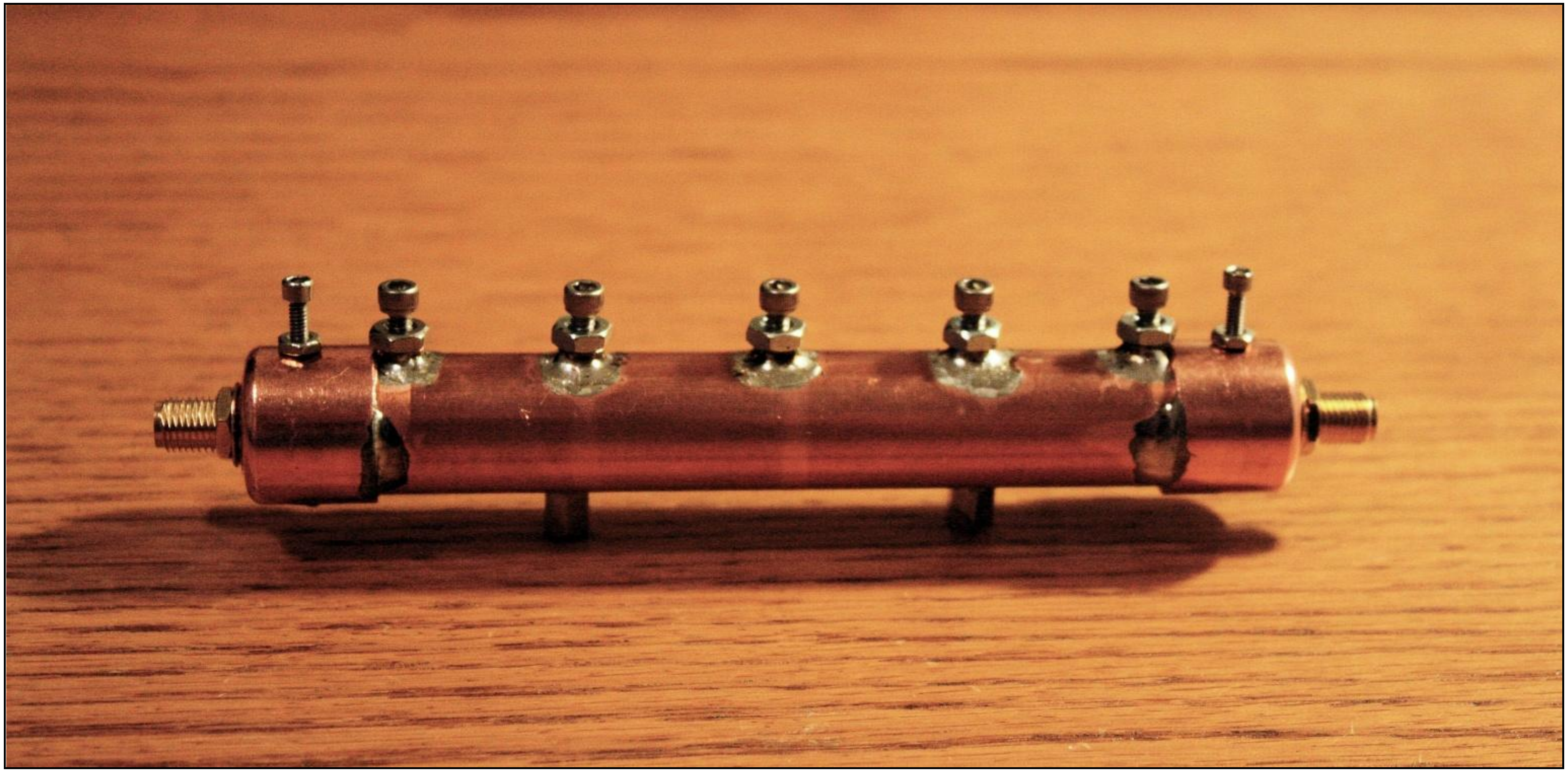
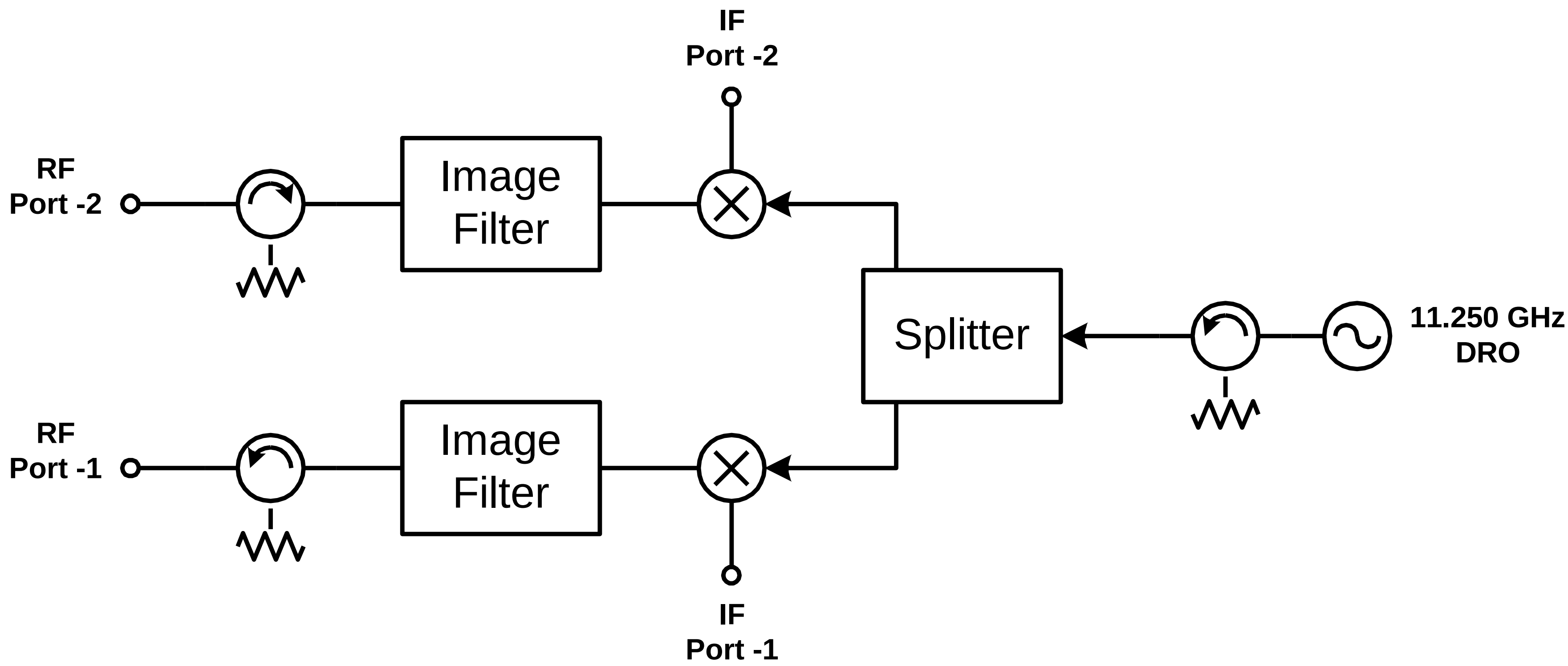
EVANESCENT MODE CIRCULAR WG FILTERS

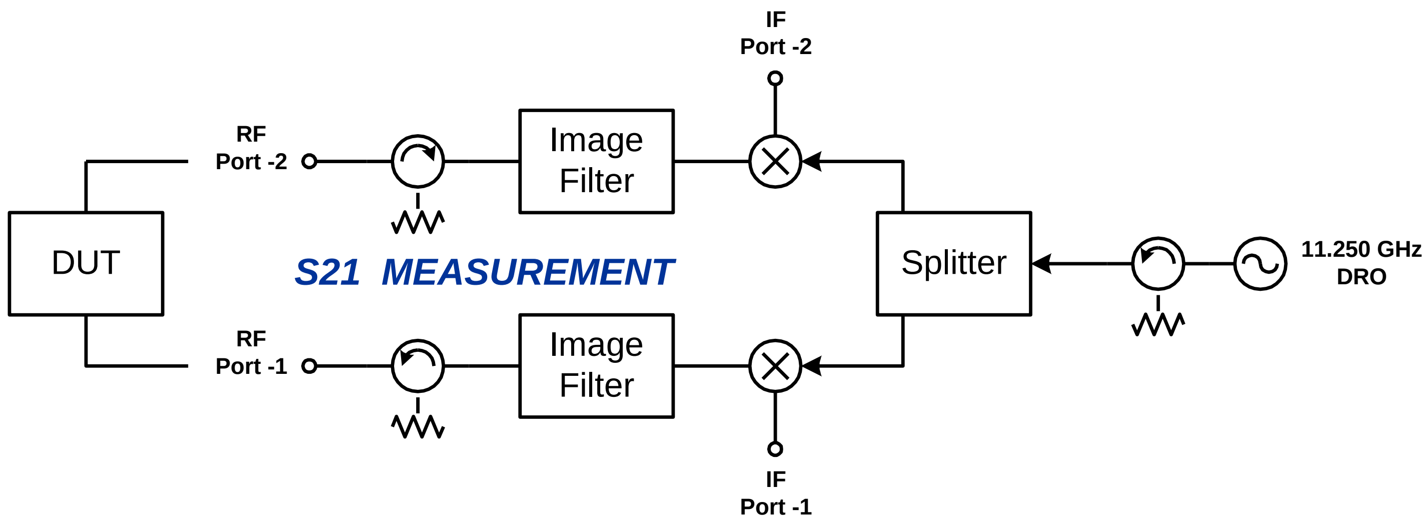


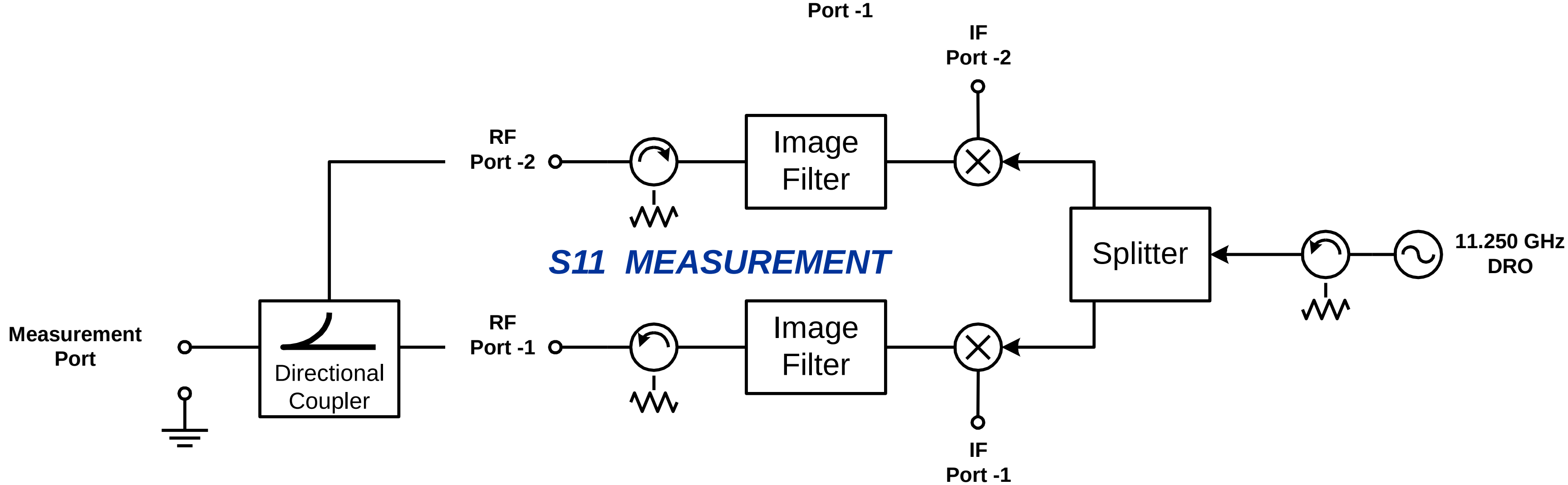
K5TRA

MOTIVATION: NEED IMAGE FILTERS for X-BAND TEST-SET



X-BAND TEST-SET CONFIGURATIONS





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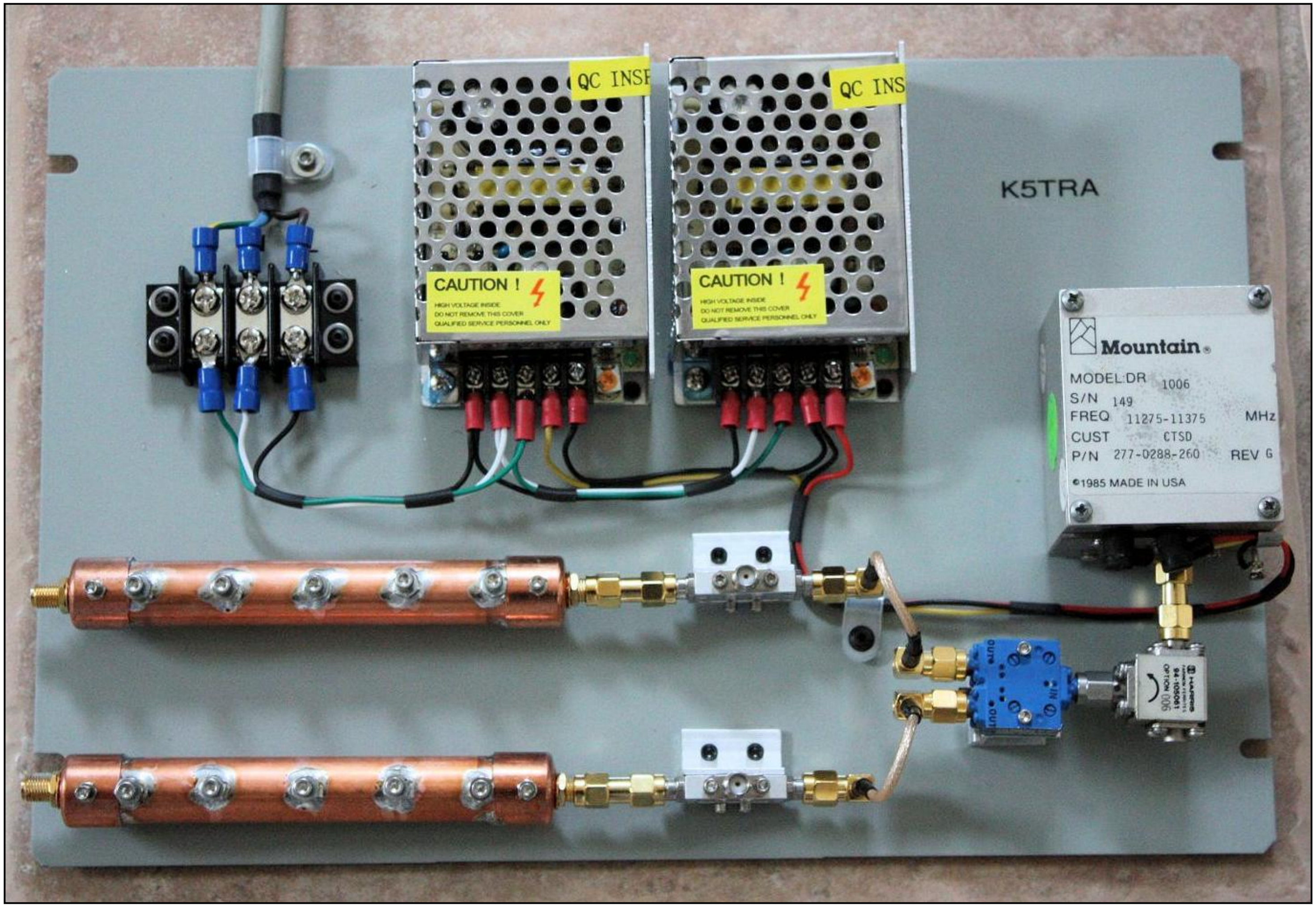
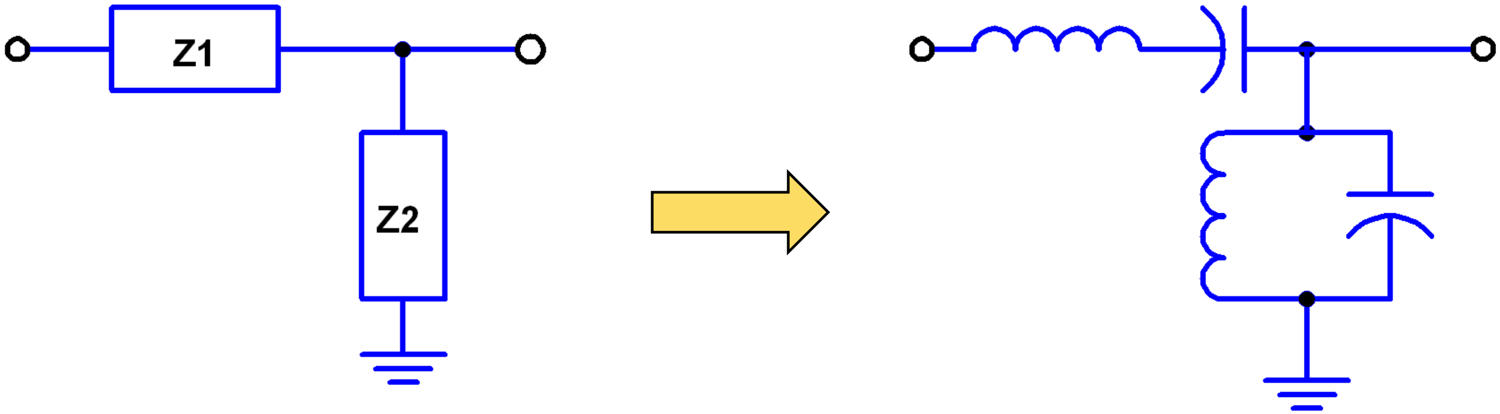
X-BAND TEST-SET

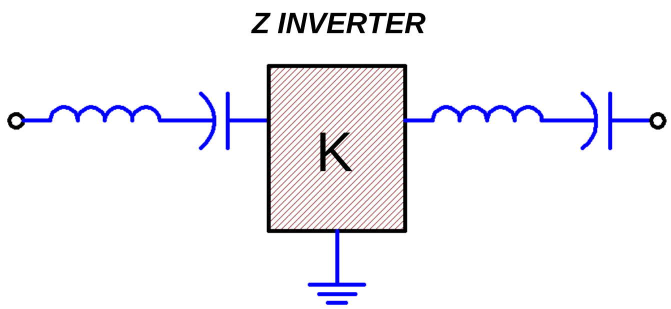


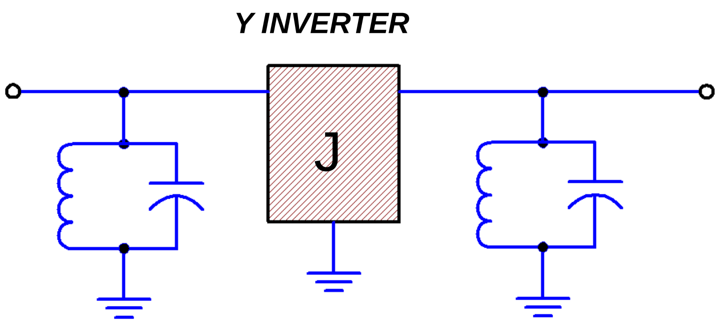
LADDER FILTER BASIC BUILDING BLOCK



- Passband: Z1 ⇨ *short* and Z2 ⇨ *open*
- Stopband: Z1 ⇨ *open* and Z2 ⇨ *short*

J and K INVERTERS PROVIDE REUSE OF RESONATOR TYPE

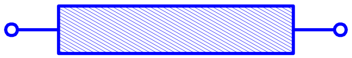




- Impedance inverter (K) with a series resonator behaves like a parallel resonator
- Admittance inverter (J) with a parallel resonator behaves like a series resonator
- Impedance/admittance inverter interface between similar resonators provides maximum stopband attenuation
- Most common impedance inverter is transmission line that is an odd multiples of $\lambda/4$

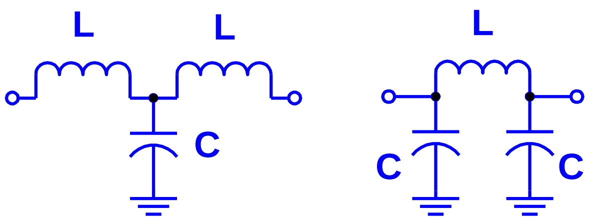
IMPEDANCE/ADMITTANCE INVERTERS

- Impedance (or admitance) inverters can be used to convert parallel resonance to a series resonance characteristic.
- The canonic impedance inverter is the λ/4 line.
- LC forms provide moderate bandwidth Z inversion.
- Capacitive T and π sections are for narrow band applications. Negative C or L is absorbed into resonator (cancels some positive C or L).

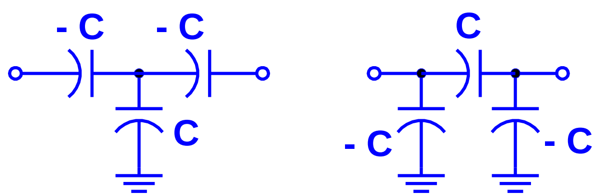


Transmission Line
J (or K) Inverter

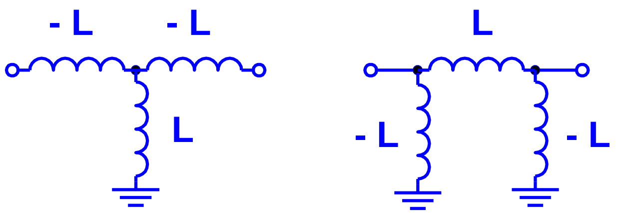
$$Z_0, \quad \theta = \frac{\lambda}{4}$$



$$Z_0 = \sqrt{\frac{L}{C}}, \quad \omega_0 = \frac{1}{\sqrt{LC}}$$

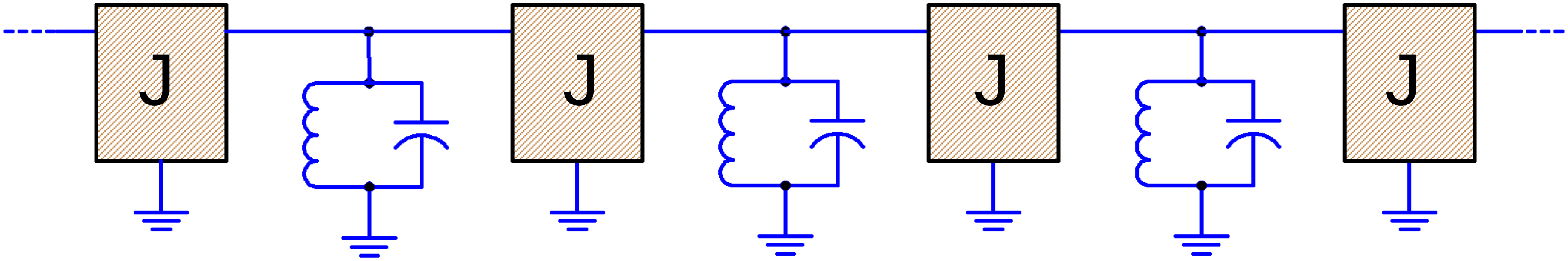


$$Z_0 = \frac{1}{\omega_0 C}$$



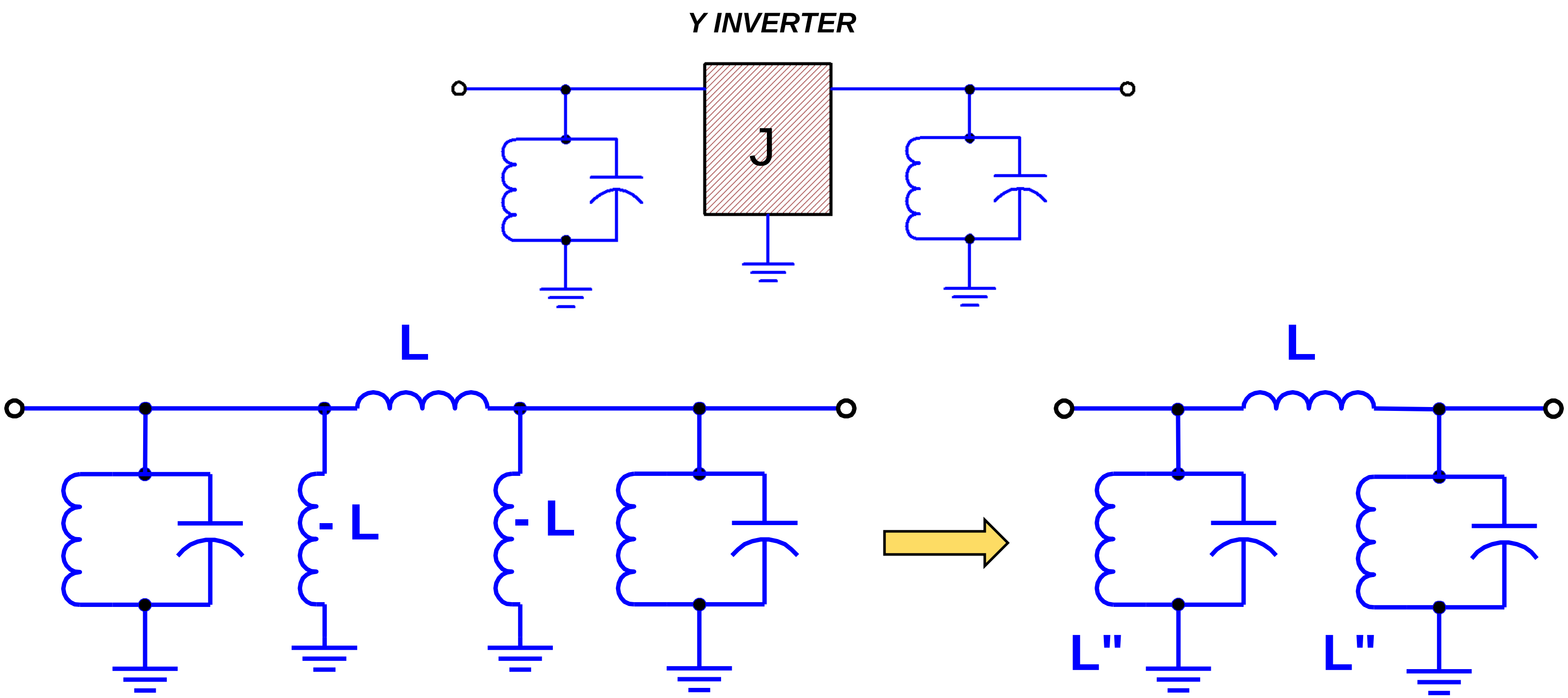
$$Z_0 = \omega_0 L$$

BANDPASS FILTER STRUCTURE WITH J INVERTERS



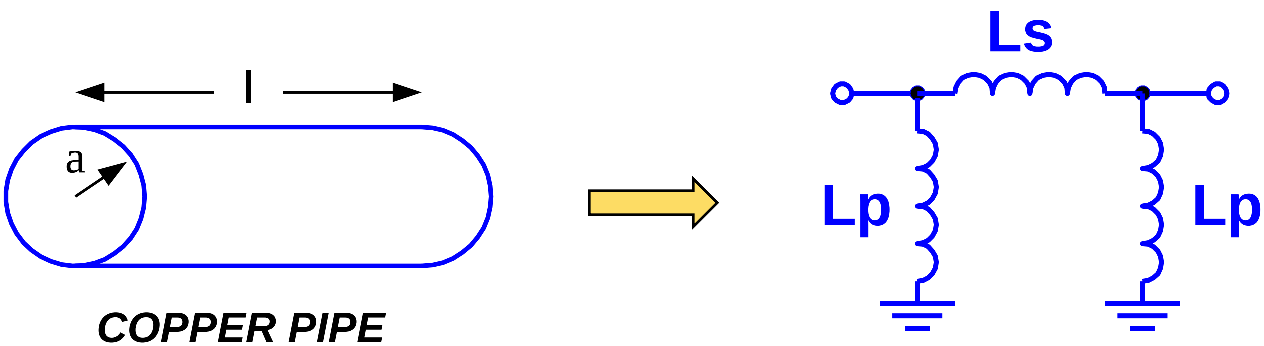
- Filters are formed as cascade of parallel resonators and inverters
- How do we realize a structure like this in WG?

BANDPASS FILTER WITH INDUCTIVE J INVERTERS



- Negative inductors of inverter cancel some of the resonator inductance
- Inverter admittance/impedance sets coupling between resonators. In this case, coupling is set by $(\omega\ L)^{-1}$

EVANESCENT WG MODEL



COPPER PIPE CIRCULAR WG

$$a = inside\ radius\ in\ mm$$

$$l = length\ of\ WG\ section$$

$$F_c = 1.8412 \times \frac{300}{2\pi\ a}$$

$$Ls = \frac{X_0 \sinh(\gamma l)}{2\pi\ freq} \qquad Lp = \frac{X_0 \coth\left(\frac{\gamma l}{2}\right)}{2\pi\ freq}$$

$$\gamma = \frac{1}{\lambda_0}\sqrt{\left[\left(\frac{F_c}{F_0}\right)^2 - 1\right]} \qquad X_0 = \frac{377}{\sqrt{\left[\left(\frac{F_c}{F_0}\right)^2 - 1\right]}}$$

$$X_0 \sim 377\ \Omega$$

- Operation *BELOW* TE_{11} cutoff frequency
- Propagation falls off quickly
- Behavior is reactive (inductive)

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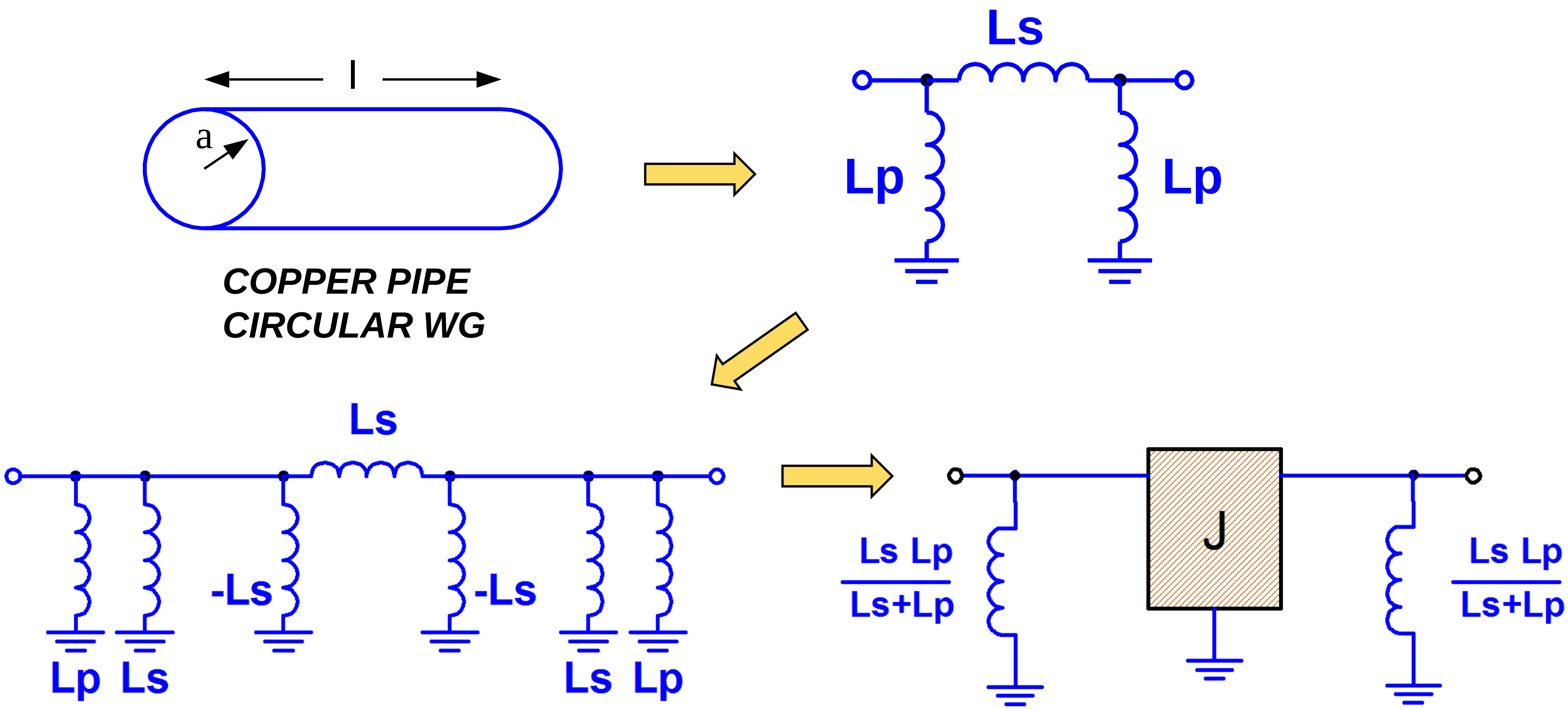
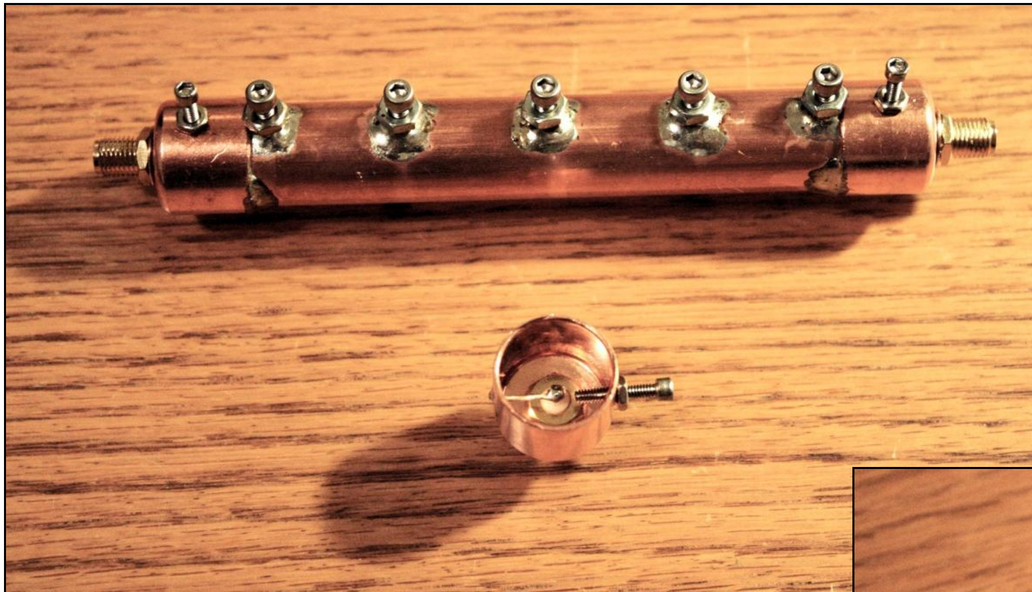
EVANESCENT WG SECTIONS PROVIDE J INVERTER and RESONATOR L

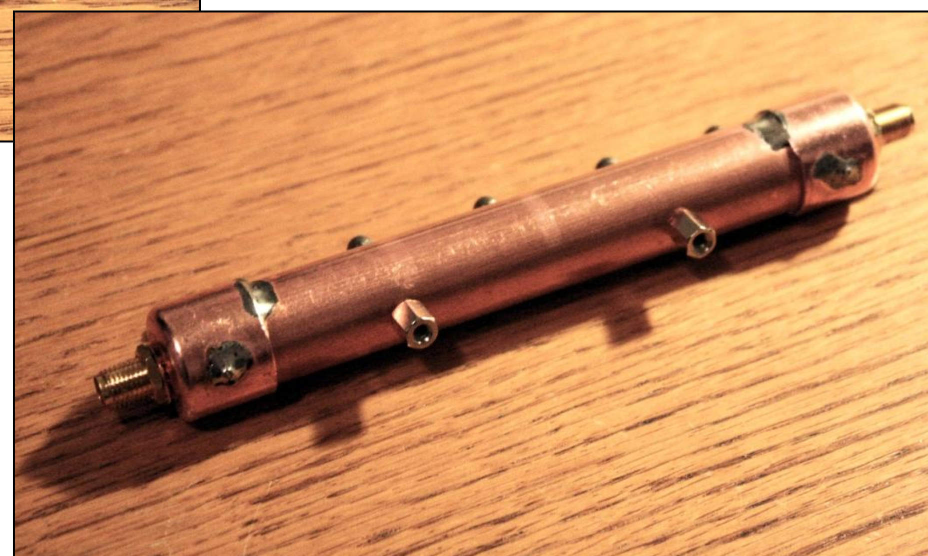


- *RESONATOR* ***C*** *CAN BE ADDED WITH TUNING SCREWS*
- *SCREW SPACING SETS Ls (SETS COUPLING)*

EVANESCENT WG FILTER CONSTRUCTION

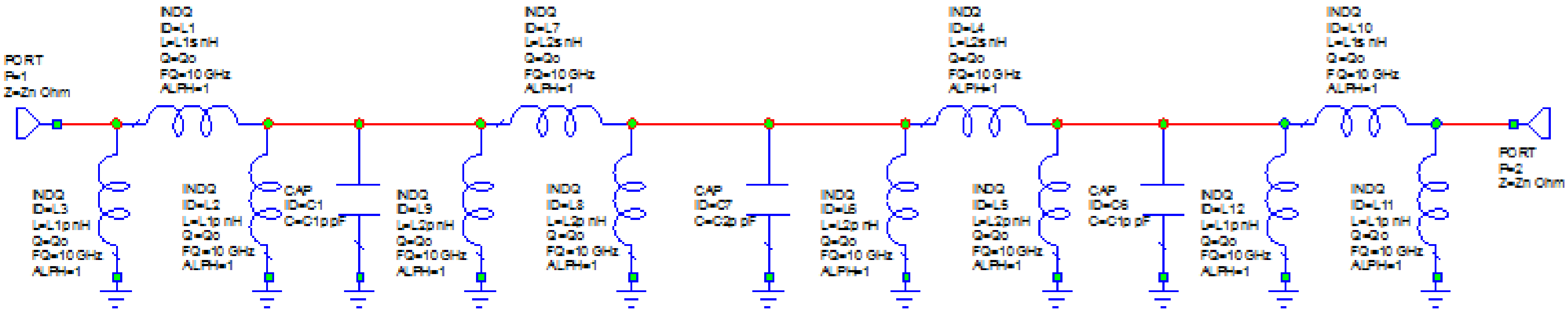


- Operation *BELOW* cutoff frequency
- 0.5” Cu pipe for X-band (actual ID = 0.565”)

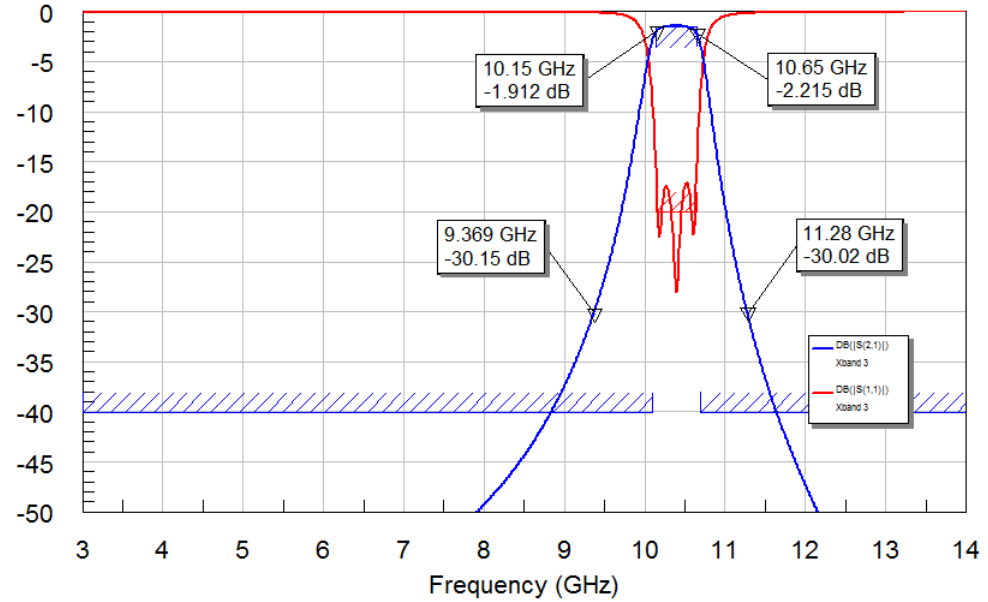


- 4-40 tuning screws
- Tapped holes and soldered brass nuts
- Stainless locking nuts
- Coupling loop with 2-56 tuning
- 0.25” 4-40 stand-off mounting

EVANESCENT WG FILTER ANALYSIS 6th ORDER EXAMPLE



l1=6.899	l2=22.27
b: 0.1367	b: 0.1367
XLs1=X0*sinh(b*l1)	XLs2=X0*sinh(b*l2)
XLs1: 410.7	XLs2: 3951
Ls1=XLs1/6.28/Fo	Ls2=XLs2/6.28/Fo
Ls1: 6.307	Ls2: 60.67
XLp1=X0*cosh(b*l1*0.50)/sinh(b*l1*0.50)	XLp2=X0*cosh(b*l2*0.50)/sinh(b*l2*0.50)
XLp1: 857.9	XLp2: 414.7
Lp1=XLp1/6.28/Fo	Lp2=XLp2/6.28/Fo
Lp1: 13.18	Lp2: 6.369
L1s=Ls1	L2s=Ls2
L1p=Lp1	L2p=Lp2
C1p=0.09485	C2p=0.08137
x1=l1/25.4	x2=l2/25.4
x1: 0.2716	x2: 0.8769



INDUCTOR Qo FOUND EMPERICALLY TO BE APPROXIMATELY 200

DESIGN TABLES N= 2, 3, & 4

N=4

%BW	BW(MHz)	l1(mil)	l2(mil)	l3(mil)	C1(pF)	C2(pF)	Loss(dB)	RetLoss(dB)	F30L(GHz)	F30H(GHz)
5	500	258	882	985	0.096	0.081	3.41	16.85	9.7	11.0
3	300	311	1018	1119	0.091	0.081	4.72	18.31	10.0	10.8
2	200	345	1109	1217	0.089	0.081	5.76	20.8	10.1	10.7
1	100	345	1150	1282	0.089	0.081	5.63	34.18	10.1	10.6
0.5	50	356	1190	1331	0.088	0.081	6.14	44.78	10.2	10.6

N=3

%BW	BW(MHz)	l1(mil)	l2(mil)	C1(pF)	C2(pF)	Loss(dB)	RetLoss(dB)	F30L(GHz)	F30H(GHz)
5	500	272	875	0.095	0.081	2.20	16.44	9.4	11.3
3	300	333	1035	0.089	0.081	3.50	14.99	9.8	10.9
2	200	359	1113	0.088	0.081	3.89	17.56	9.9	10.8
1	100	394	1225	0.086	0.081	4.84	21.00	10.1	10.7
0.5	50	424	1298	0.085	0.081	5.70	29.76	10.2	10.6

N=2

%BW	BW(MHz)	l1(mil)	l2(mil)	C1(pF)	Loss(dB)	RetLoss(dB)	F30L(GHz)	F30H(GHz)
5	500	254	752	0.097	1.06	14.43	7.0	12.4
3	300	300	882	0.092	1.36	16.57	8.4	11.8
2	200	338	977	0.089	1.69	18.52	9.0	11.5
1	100	412	1152	0.086	2.73	17.93	9.7	11.0
0.5	50	441	1240	0.085	3.36	19.02	9.8	10.9

DESIGN TABLES N= 5, & 6

N=6

%BW	BW(MHz)	l1(mil)	l2(mil)	l3(mil)	l4(mil)	C1(pF)	C2(pF)	C3(pF)	Loss(dB)	RetLoss(dB)	F30L(GHz)	F30H(GHz)
5	500	226	834	983	1003	0.110	0.081	0.081	5.26	24.13	9.9	10.7
3	300	291	987	1120	1141	0.093	0.081	0.081	7.37	25.86	10.1	10.7
2	200	310	1059	1218	1253	0.091	0.081	0.081	9.36	29.91	10.2	10.6
1	100	306	1082	1274	1314	0.091	0.081	0.081	8.93	49.56	10.2	10.6
0.5	50	210	884	1425	1532	0.095	0.080	0.081	8.91	46.15	10.2	10.6

N=5

%BW	BW(MHz)	l1(mil)	l2(mil)	l3(mil)	C1(pF)	C2(pF)	C3(pF)	Loss(dB)	RetLoss(dB)	F30L(GHz)	F30H(GHz)
5	500	230	832	973	0.101	0.081	0.081	3.61	23.87	9.8	10.9
3	300	276	962	1101	0.094	0.081	0.081	4.92	25.36	10.0	10.8
2	200	293	1021	1173	0.093	0.081	0.081	5.62	33.02	10.1	10.7
1	100	334	1138	1308	0.089	0.081	0.081	7.92	39.68	10.2	10.6
0.5	50	328	1138	1323	0.089	0.081	0.081	7.68	51.7	10.2	10.6

EVANESCENT WG FILTER