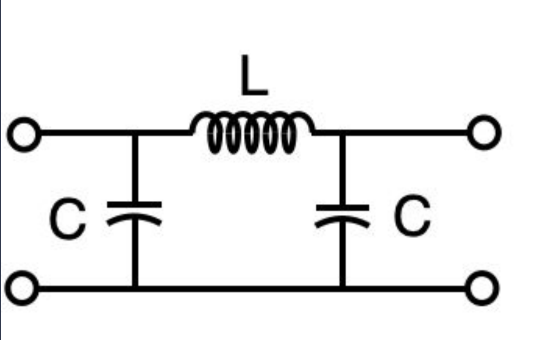
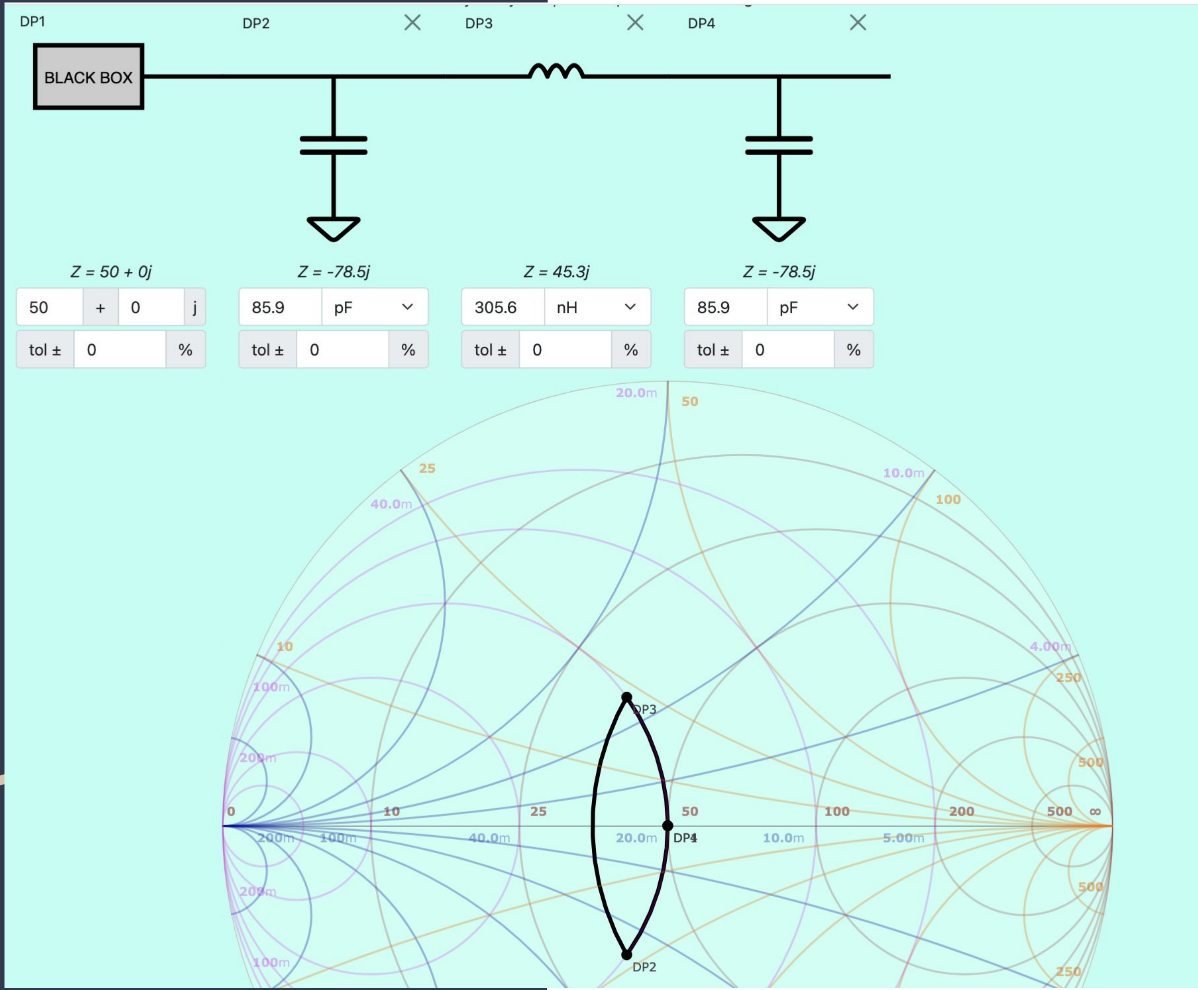
Pi Phase Shifter

By: Kyle Woo

What is pi phase shifter.



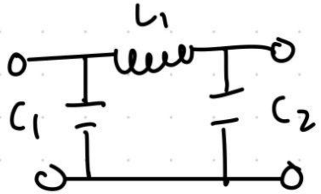
- The phase shifter provides precise phase control at a specific frequency by leveraging reactive components to manipulate the signal's phase and impedance.
- A π-phase shifter introduces a "specific phase shift" to a signal
  - Composed of: two shunt capacitors (C) and one series inductor (L)
- Capacitors (C): Add **phase lead** (negative reactance).
- Inductor (L): Adds **phase lag** (positive reactance).


DP1
DP2
DP3
DP4
BLACK BOX
Z = 50 + 0j
Z = -78.5j
Z = 45.3j
Z = -78.5j
50 + 0 j
85.9 pF
305.6 nH
85.9 pF
tol ± 0 %
tol ± 0 %
tol ± 0 %
tol ± 0 %

$f = 23.6 \text{ MHz}$ $\omega = 2\pi f = 1.482 \times 10^8$

phase of $130°$ shift $\rightarrow$ $65°$ for half wavelength π phase shifter

Radians: $\frac{65\pi}{180}$

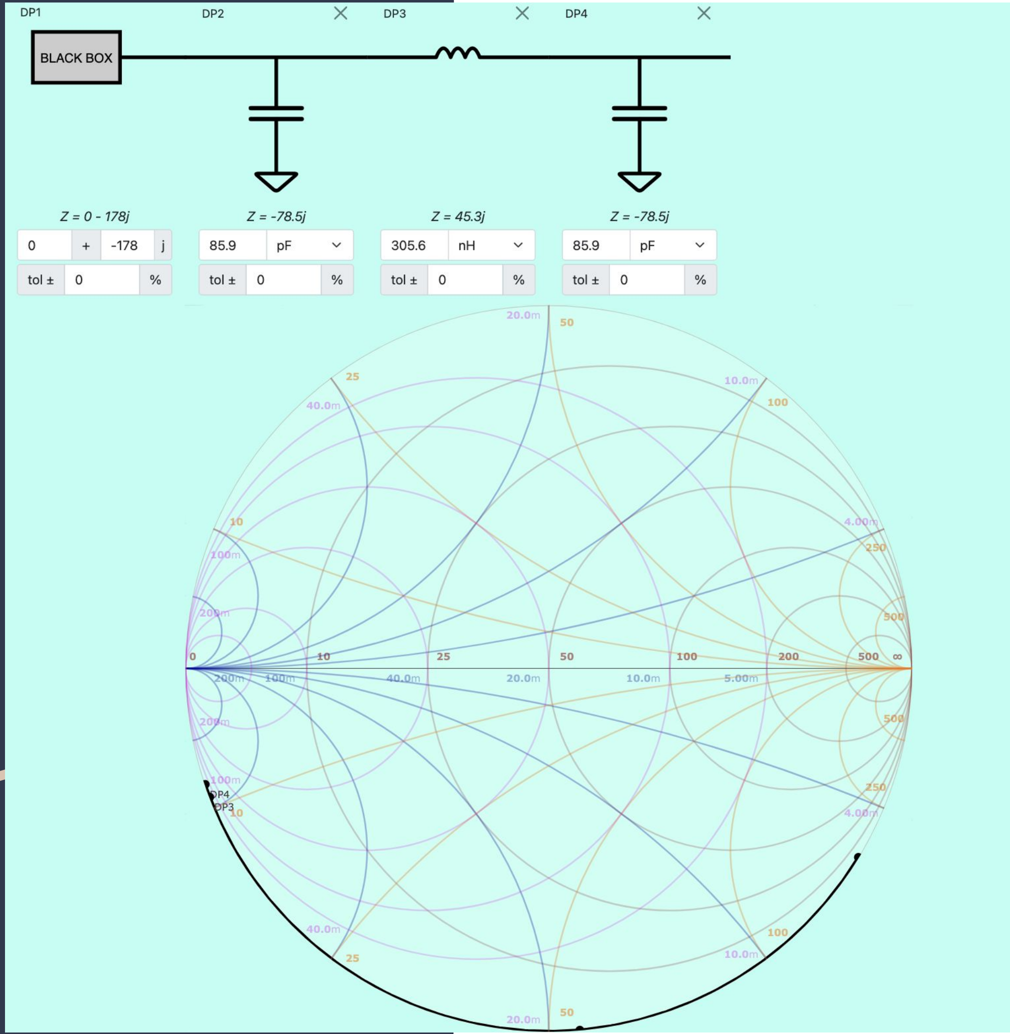


$$L\omega = Z_0 \sin(\beta l)$$

$$L = \frac{Z_0 \sin(\beta l)}{\omega} = \frac{50(0.906)}{1.482 \times 10^8} = 305.6 \text{ nH}$$

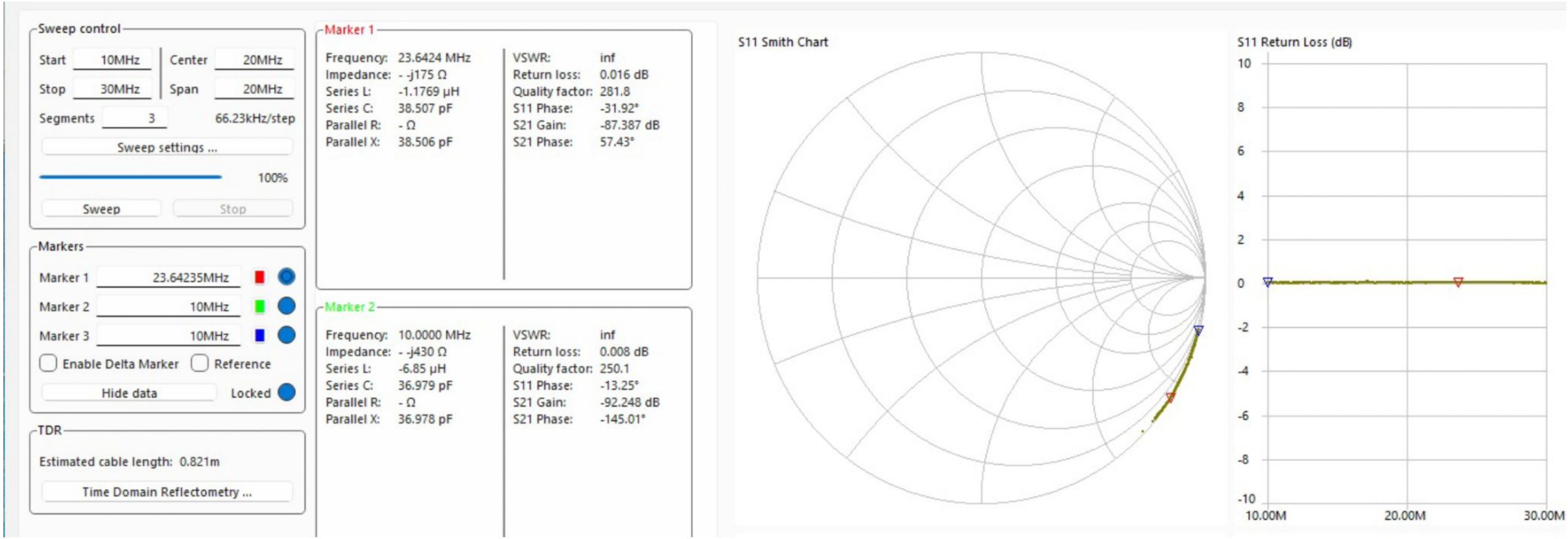
$$C\omega = \frac{\sin(\beta l)}{Z_0(1+\cos(\beta l))}$$

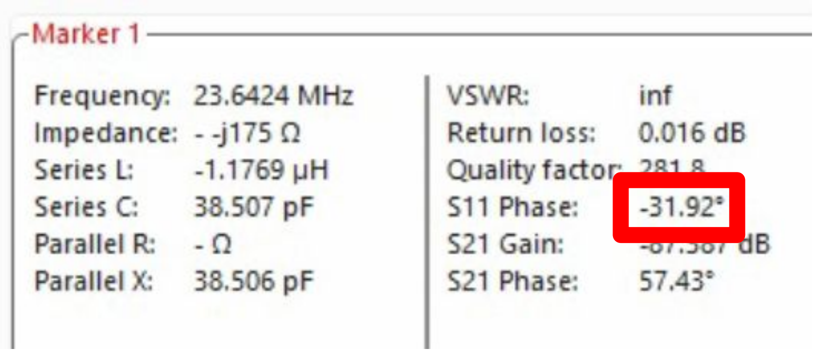
$$C = \frac{\sin(\beta l)}{\omega Z_0(1+\cos(\beta l))} = \frac{(0.906)}{50(1.482 \times 10^8)(1+0.423)} = 85.9 \text{ pF}$$


DP1
DP2
DP3
DP4
BLACK BOX
Z = 0 - 178j
0
+
-178
j
tol ±
0
%
Z = -78.5j
85.9
pF
tol ±
0
%
Z = 45.3j
305.6
nH
tol ±
0
%
Z = -78.5j
85.9
pF
tol ±
0
%

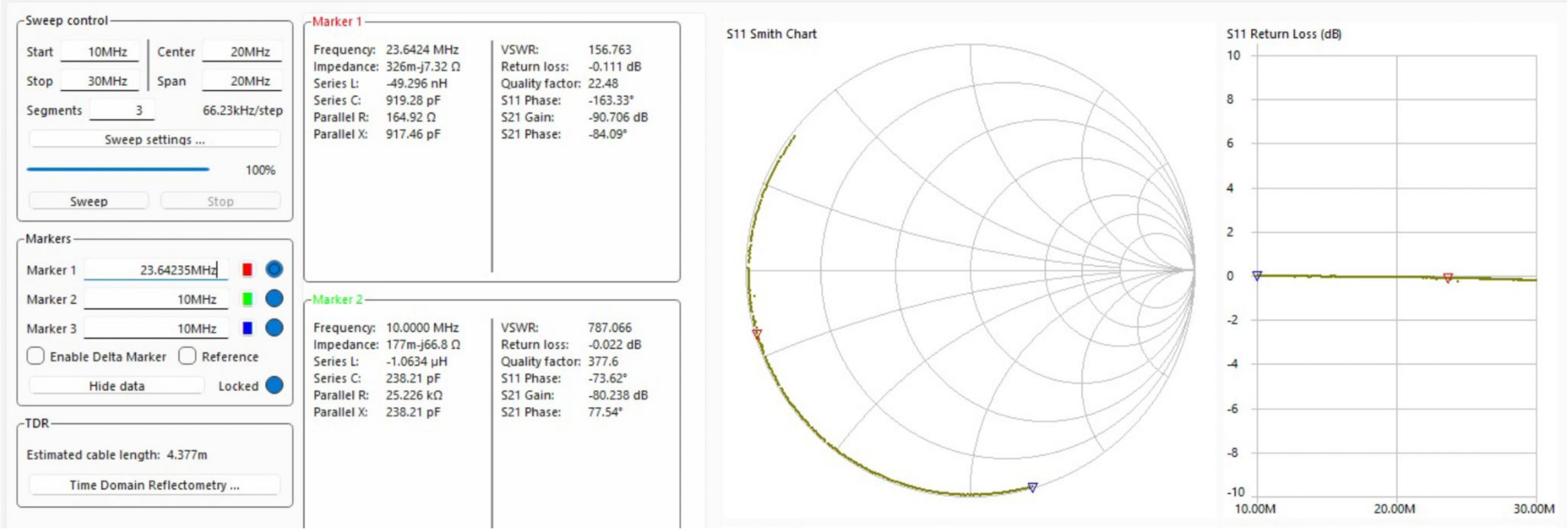
The actual values were:
37.7pF for the initial capacitor

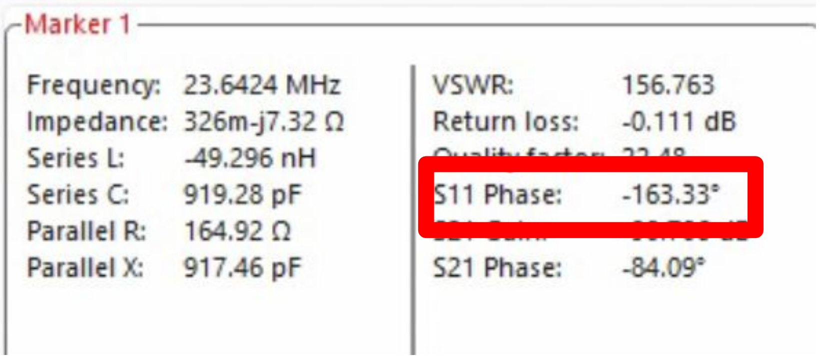
85.9pF for the two parallel capacitors (39pF + 82pF)
301nH for the inductor (subject to slight variance due to stretch and compression of coils)





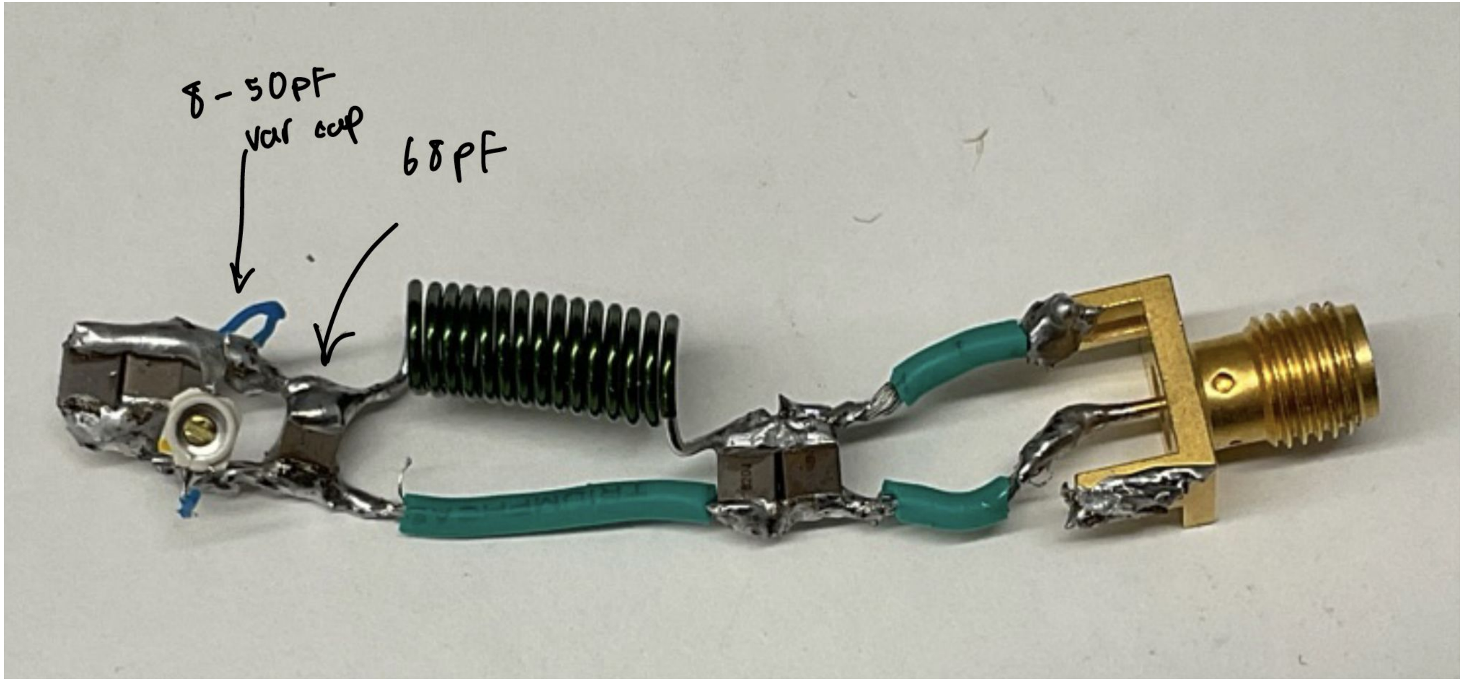
Initial phase was around -32 degrees for the singular capacitor

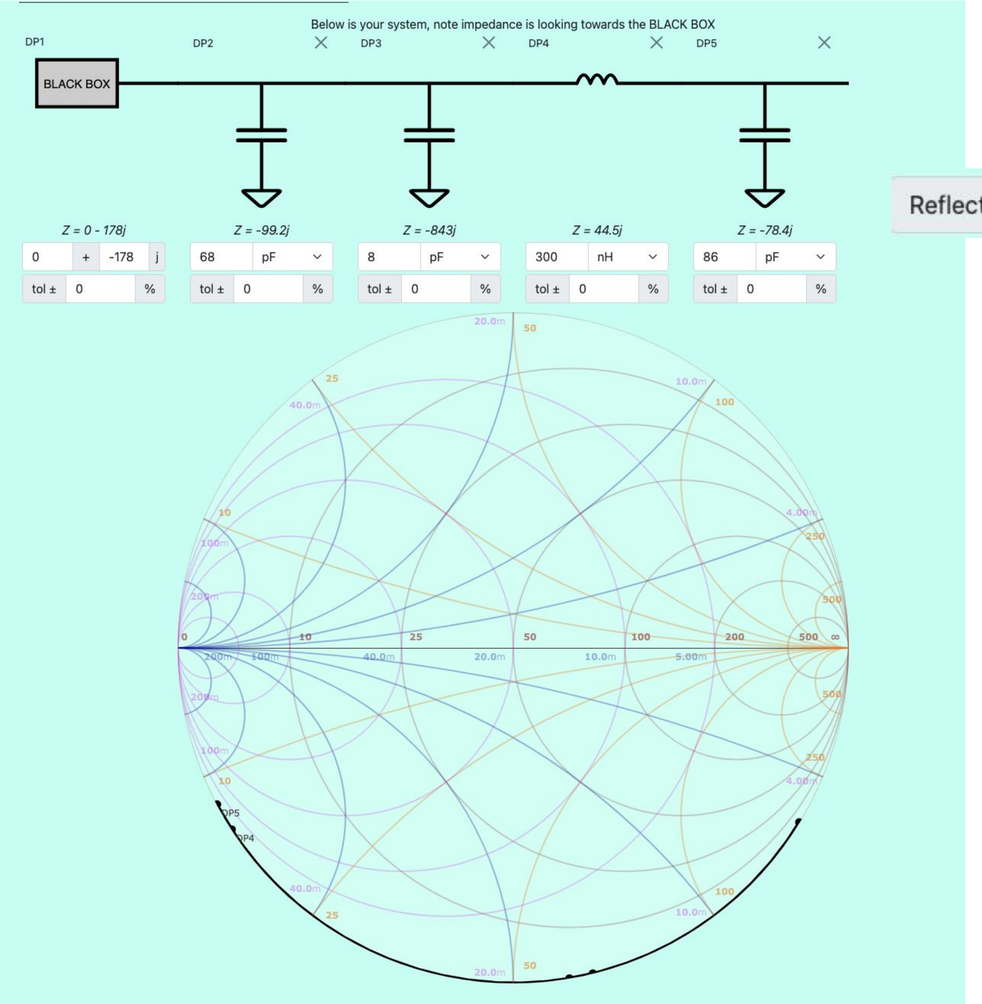




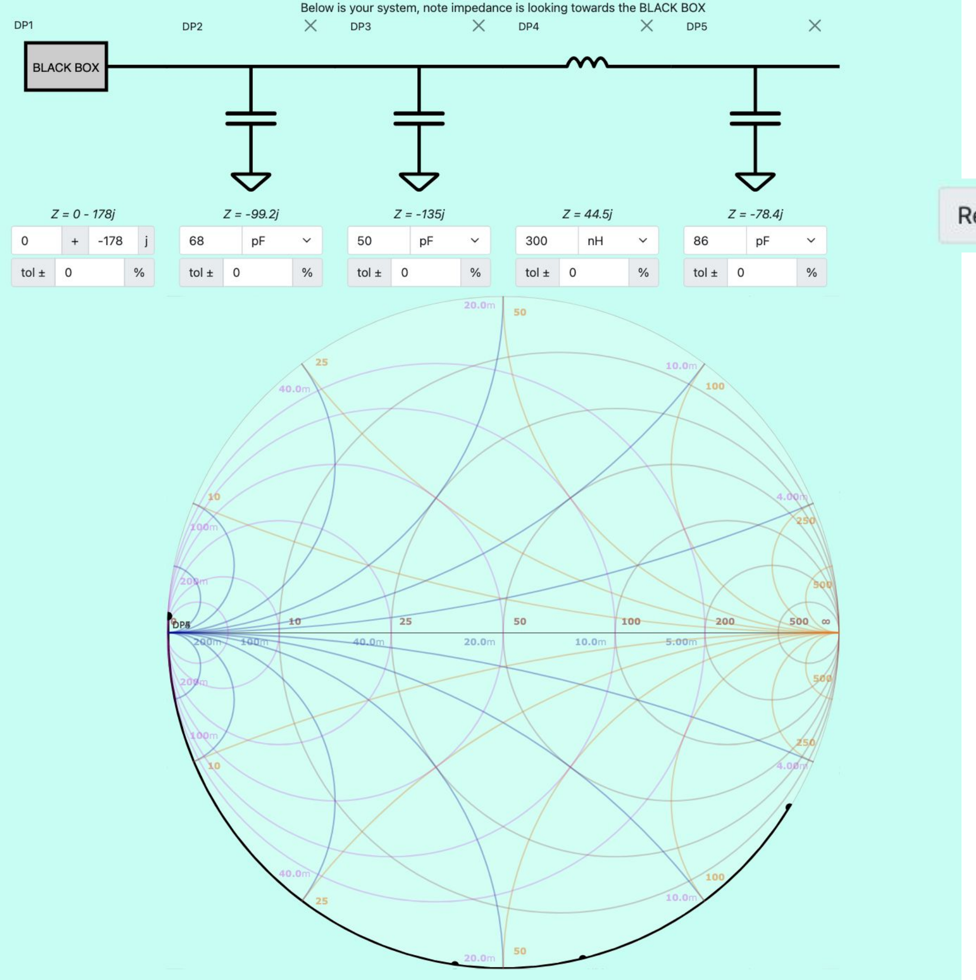
Had a phase shift of
approximately 130 degrees.

Now we move onto to the version with a variable cap

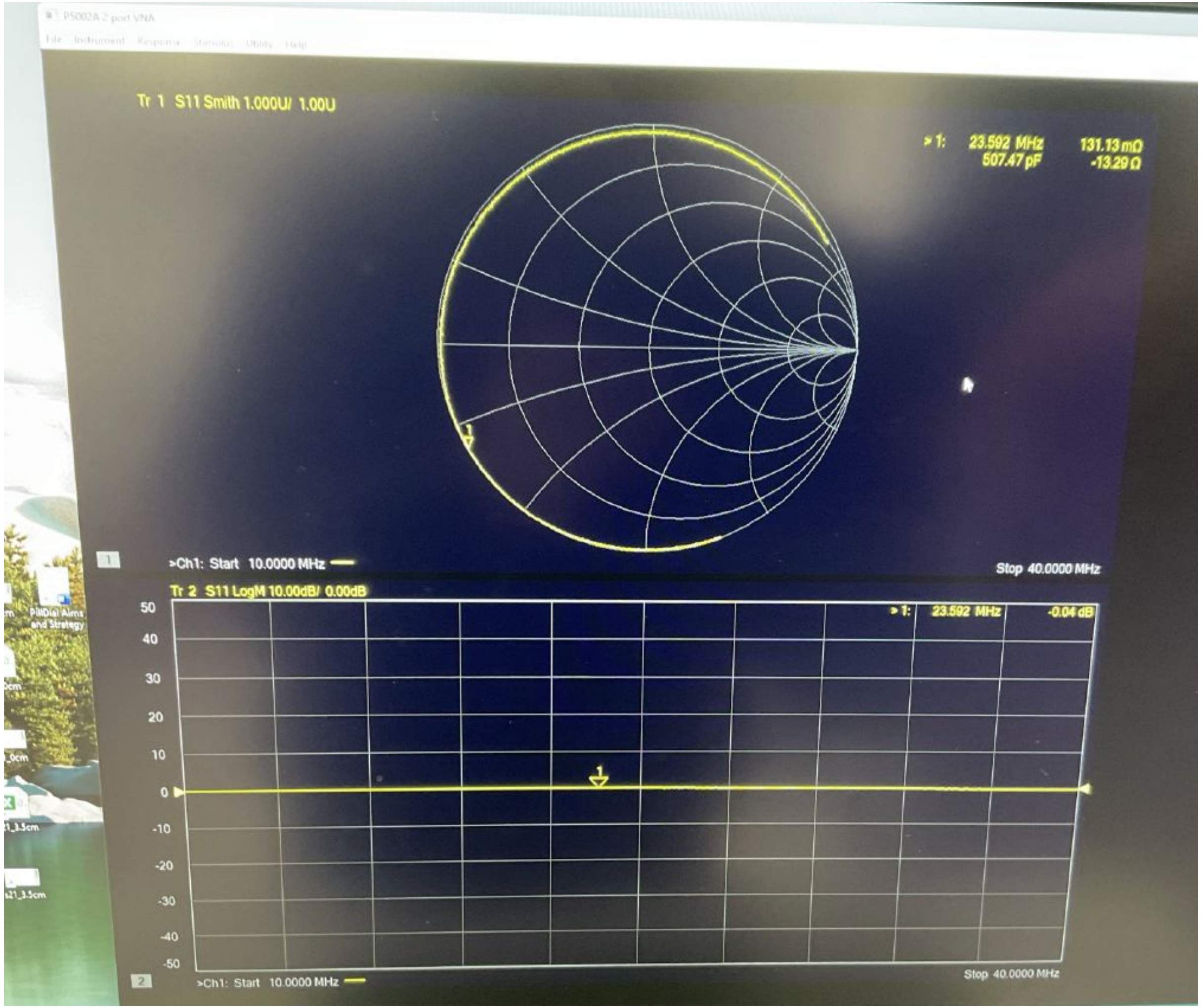




Reflection Coefficient	1.00 ∠ 208°



Reflection Coefficient 1.00 ∠ 177°



The measured phase is roughly -160 degrees, which matches our intended target. When the variable capacitor is adjusted, the phase changes by about ±20 degrees in either direction.