THEORY AND TESTING OF DUPLEXERS

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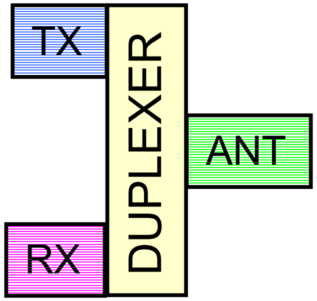
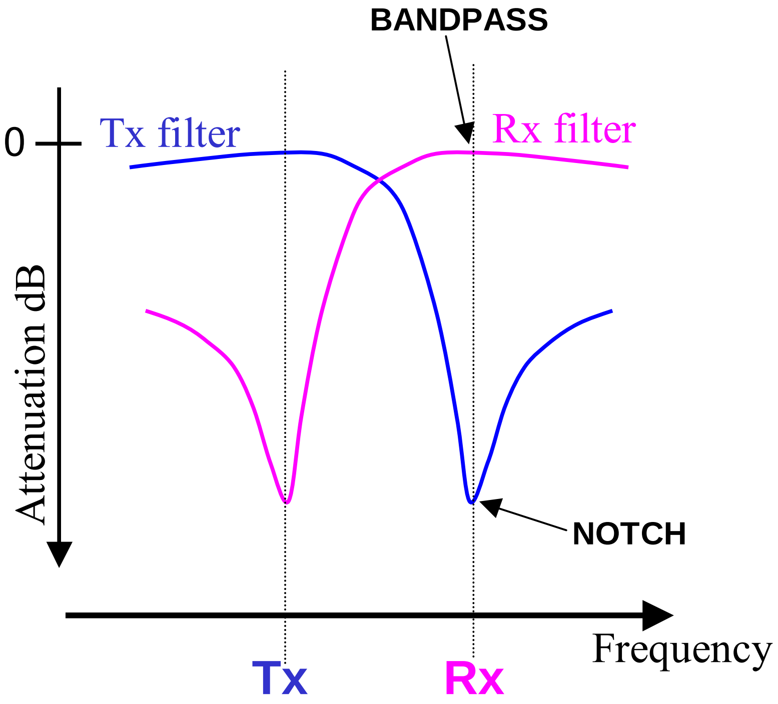
- INTRO
- WHY USE DUPLEXERS ?
- BASIC TYPES OF DUPLEXERS
- SIMPLE LC MODELS FOR EACH TYPE
- ADJUSTMENT AND VERIFICATION
- PUTTING IT ALL TOGETHER - EXAMPLES
- PITFALLS
- REFERENCES

WHY USE DUPLEXERS ?

DUPLEXERS…

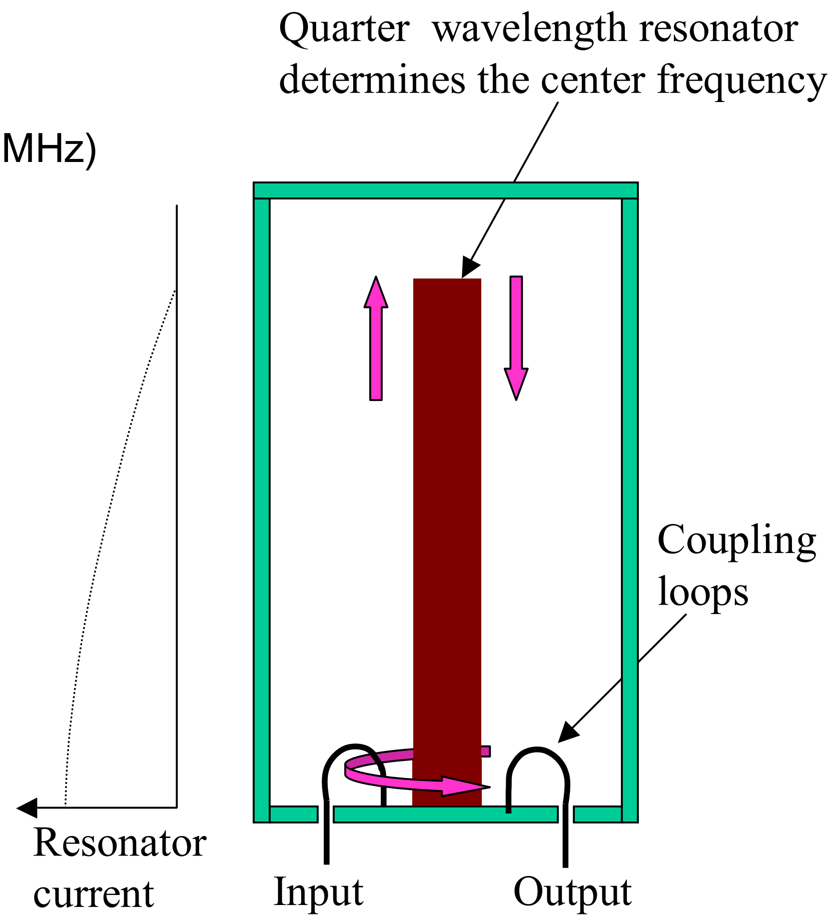
- Allow simultaneous transmit and receive on the same antenna
- The Rx filter attenuates the TX signal ~ 75 dB or more (approx 30 million times) and vice-versa
- The Tx filter attenuates the TX broadband noise being fed into the Rx by a similar amount
- Three port devices:





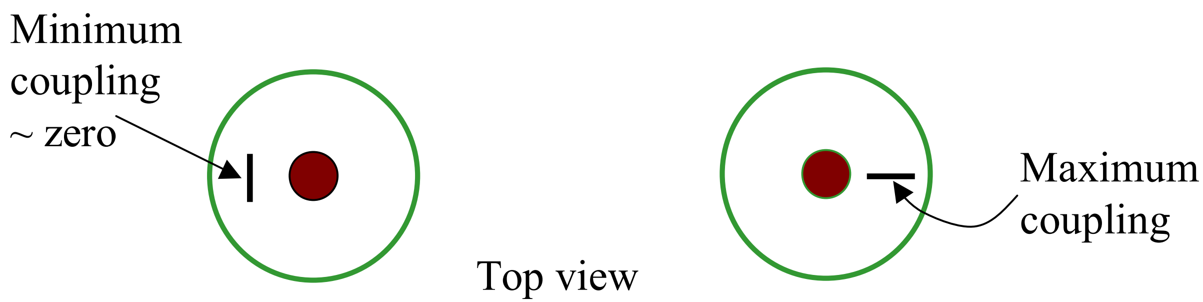
CAVITIES IN GENERAL

- Use a very low loss transmission line to improve selectivity (high Q) (~0.08 dB loss / 100 ft for a 6 in. cavity @ 150 MHz)
- The resonator acts as a quarter wave antenna inside a closed box, with max. current at the base
- In – out loops magnetically couple energy to the resonator
- Capacitive coupling may also used but not discussed here
- There is a 180 degree phase reversal between the in – out signals.



LOOP COUPLING TO THE RESONATOR

- Loop orientation affects coupling:



- Loop size: increasing the loop size increases coupling and its inductance as well

- Loop proximity from the resonator: placing the loop closer will increase coupling.

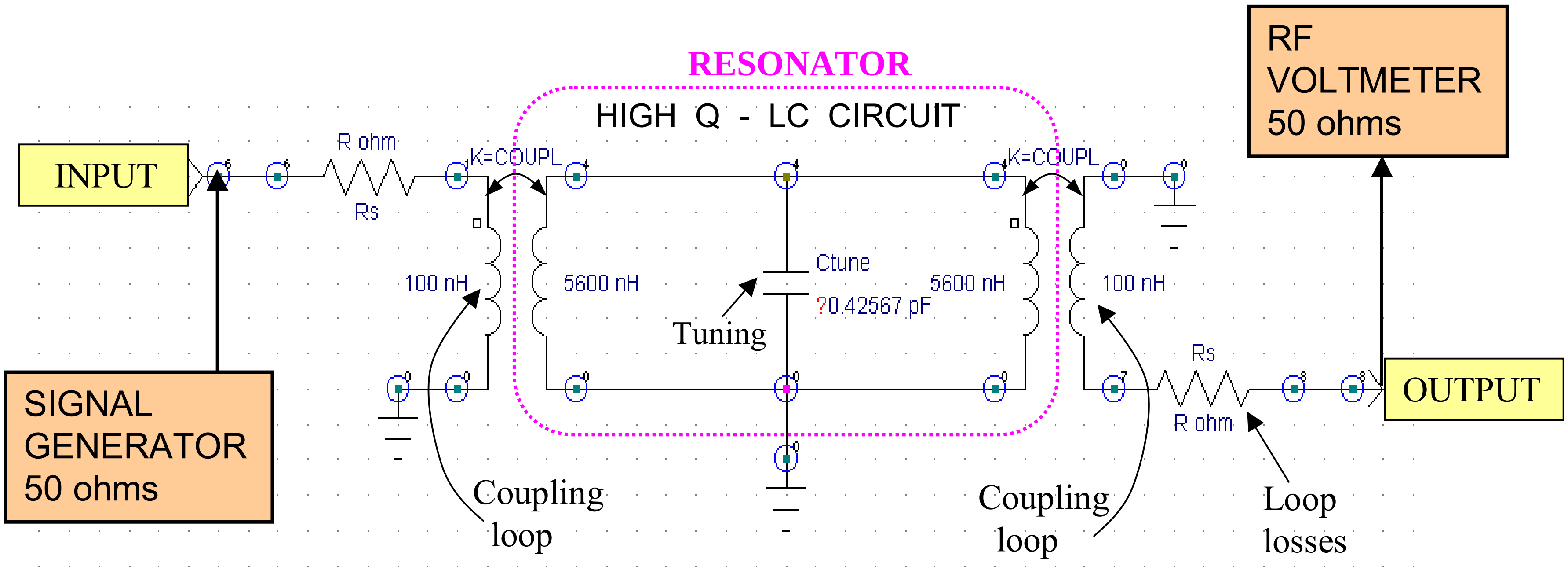
- Loop coupling affects the insertion loss and selectivity in the bandpass region and the notch frequency in notch-bandpass designs.

BASIC TYPES OF DUPLEXERS

	TX – RX FREQ SEPARATION
❑ LO – HI PASS FILTERS	WIDE
❑ BANDPASS CAVITIES	MEDIUM
❑ NOTCH – BANDPASS CAVITIES	NARROW
❑ NOTCH CAVITIES	NARROW

BANDPASS CAVITIES

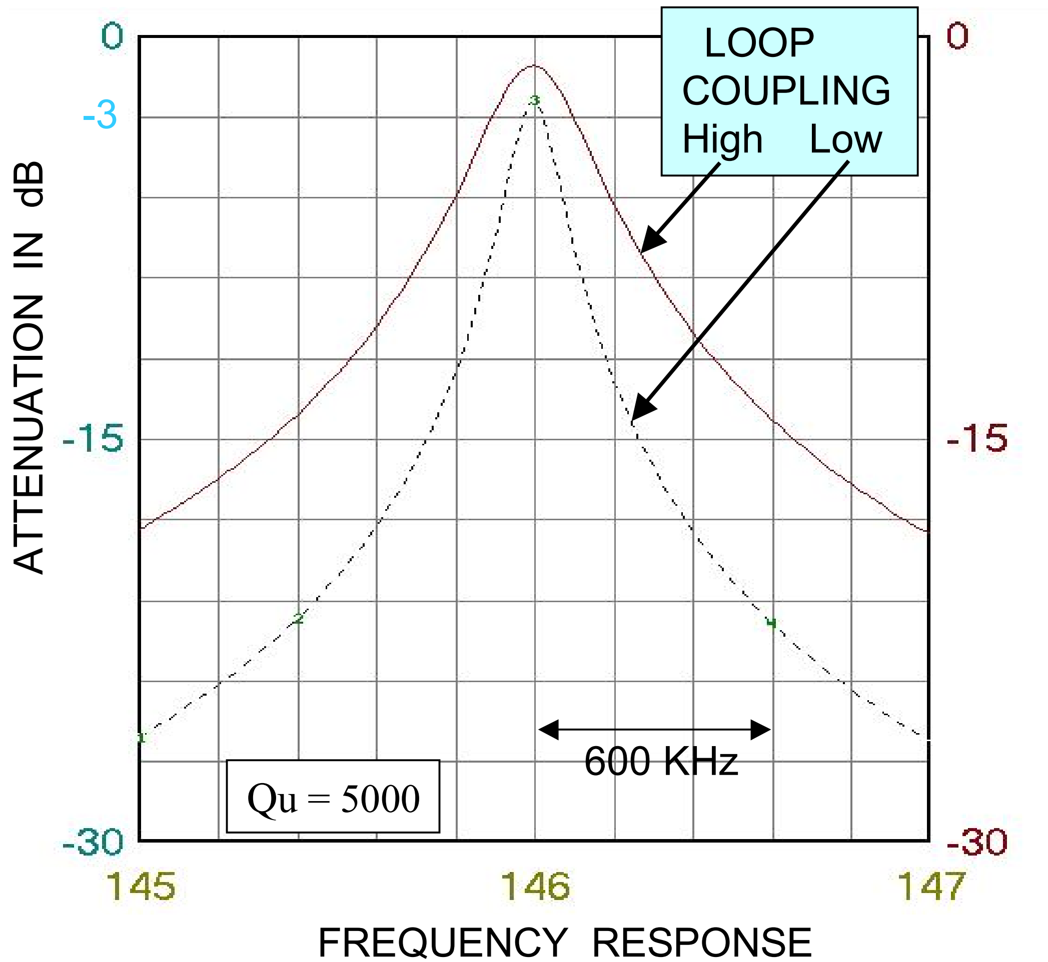
EQUIVALENT CIRCUIT



- THE QUARTER WAVELENGTH RESONATOR IS MODELED WITH A HIGH Q - LC CIRCUIT
- TYPICAL RESONATOR Qu VALUES: 2100 for 4 in. Cavity, 5000 for a 6 in. cavity

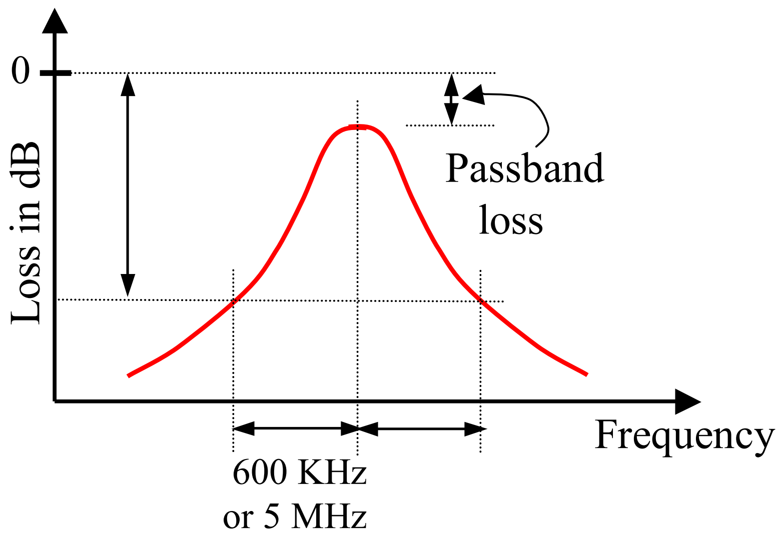
BANDPASS RESONATOR RESPONSE CURVES

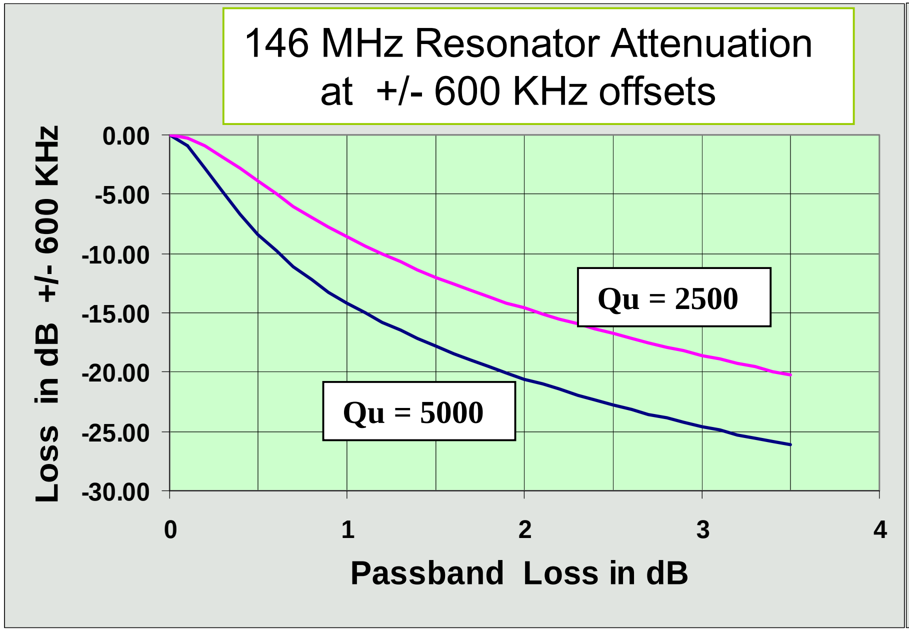
- ❑ CHANGING THE COUPLING TRADES BANDPASS LOSS FOR SELECTIVITY
- ❑ THE Q OF THE COUPLING LOOPS DOES NOT AFFECT THE RESPONSE IF: Q > 100

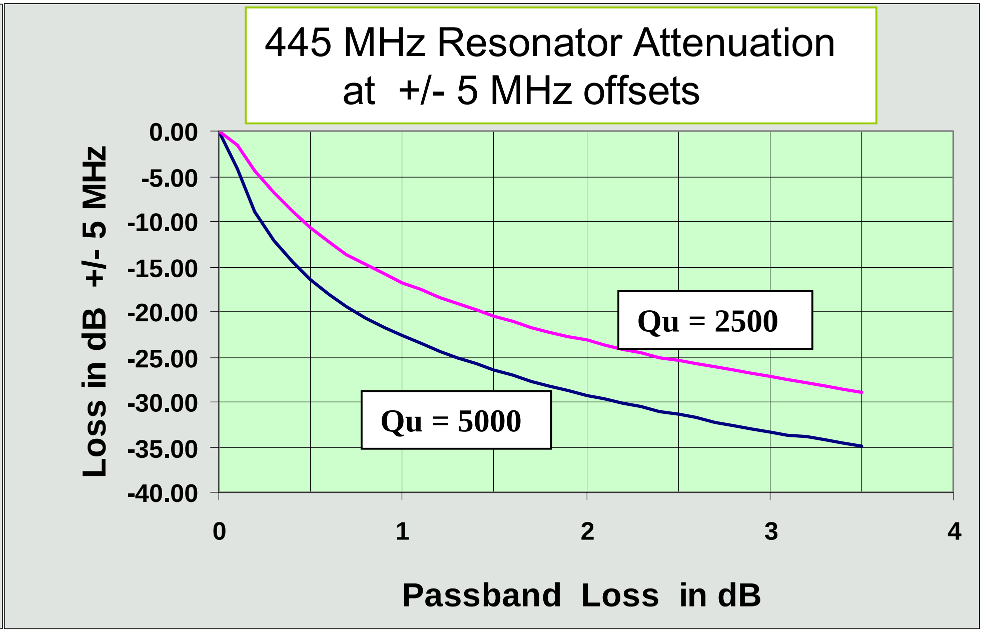


RESONATOR Qu , PASSBAND LOSSES AND SELECTIVITY

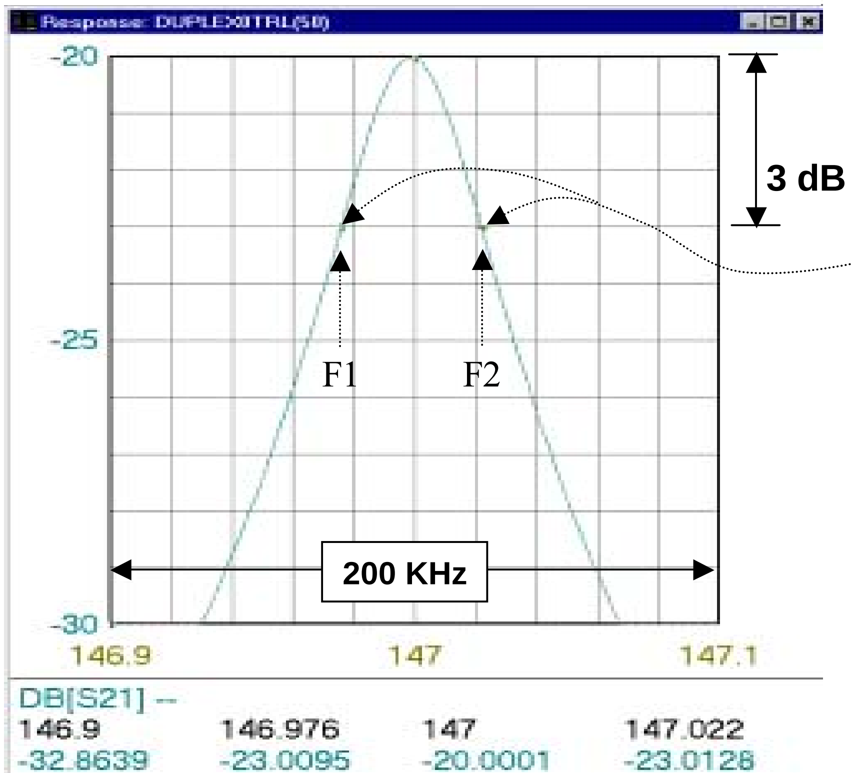
- Qu IS THE QUALITY FACTOR OF THE RESONATOR (unloaded Q)
- Qu INFLUENCES THE PASSBAND LOSSES AND THE ATTENUATION AWAY FROM THE PASSBAND
- ONE MAY TRADE PASSBAND LOSS FOR SELECTIVITY AND VICE-VERSA







MEASURING THE Qu FACTOR (Unloaded Q of the cavity)



- Adjust the coupling loops to obtain <u>~ 20 dB loss in the passband</u>
- Mesure and note the frequencies F1 and F2 (in MHz) that give 3 dB atténuation w/r to the peak:
- Calculate the quality facteur **Qu:**

$$\mathbf{Qu} = \frac{F1 + F2}{2*(F2 - F1)}$$

(Use F2 > F1)

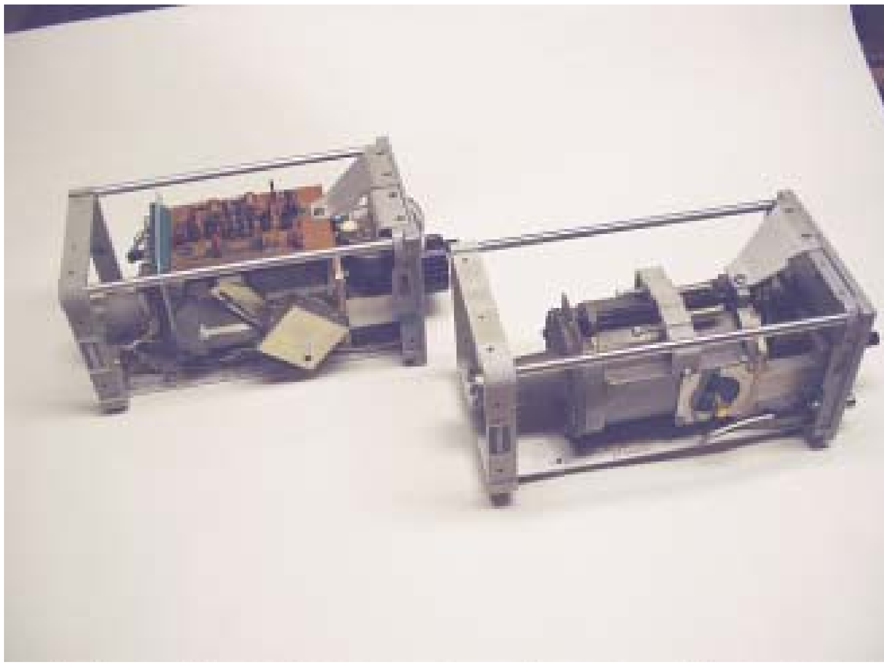
A 6 in. VHF cavity should yield Qu > 4000, typically 5000

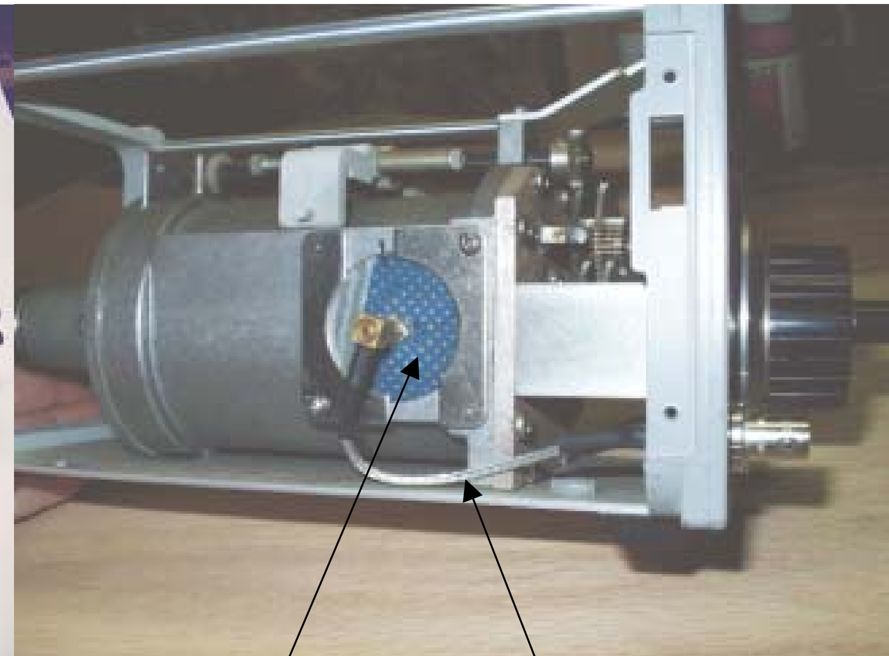
Measured values on a 6 in. cavity (notch): Q = 4650 (Davicom Technologies Inc modèle BR-15107)
On a 6 in. bandpass cavity: Q = 5675 (Sinclair FP20107*3)

A MINIATURE BANDPASS CAVITY FROM HP

- This is model HP 5253 Plug-in Frequency Converter
- Easily modified to form a bandpass cavity
- Covers 50 - 500 MHz frequency range

A MINIATURE BANDPASS CAVITY FROM HP



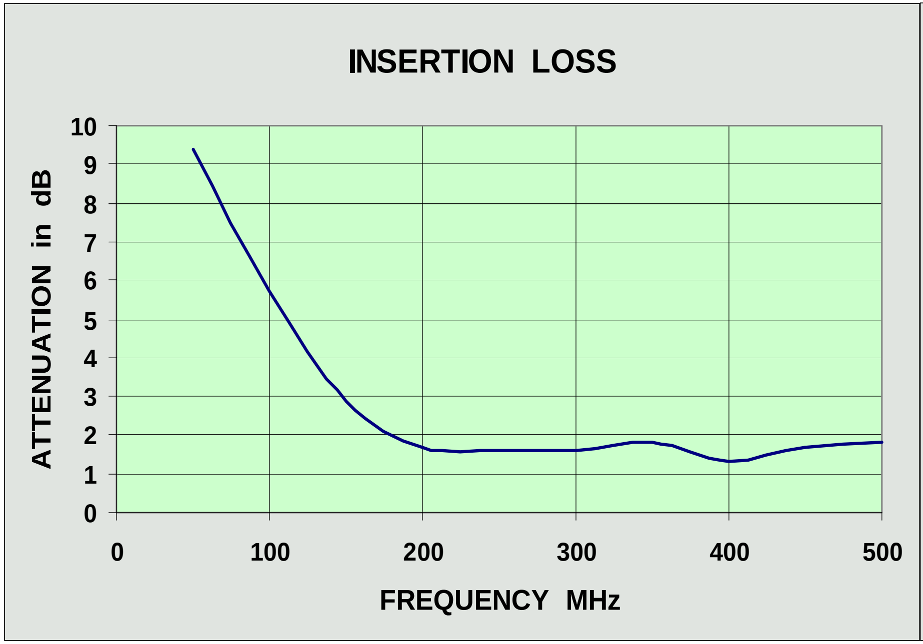


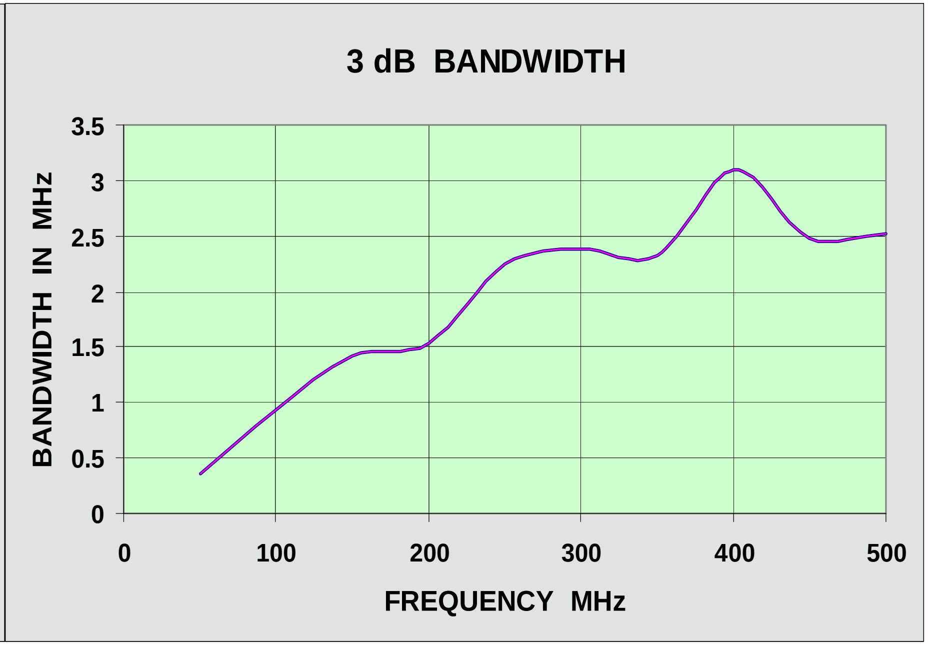
Adding the loop and cable
(both sides)

A MINIATURE BANDPASS CAVITY FROM HP

Details of the coupling loop

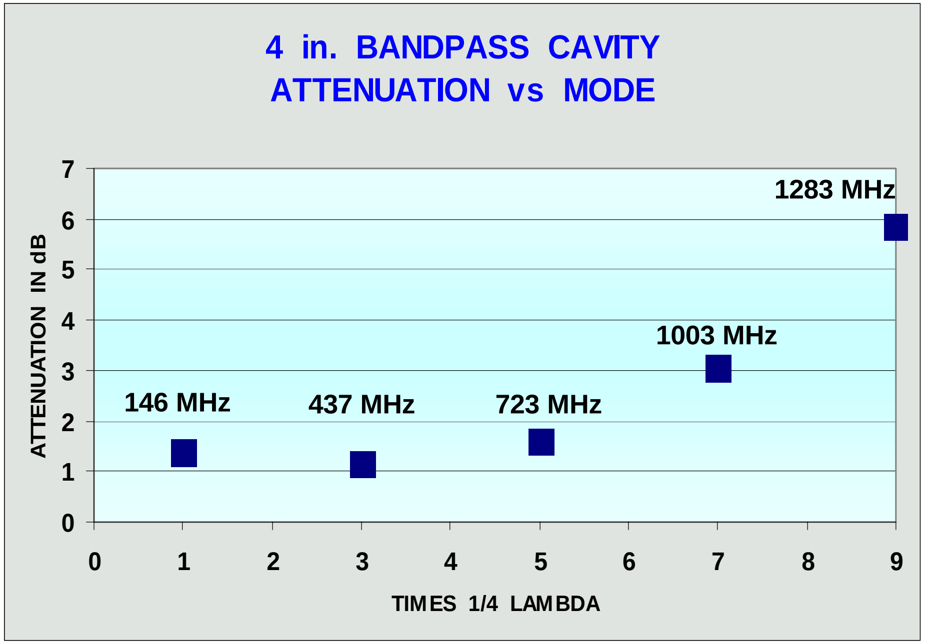
Note: loops are oriented at right angle of each other

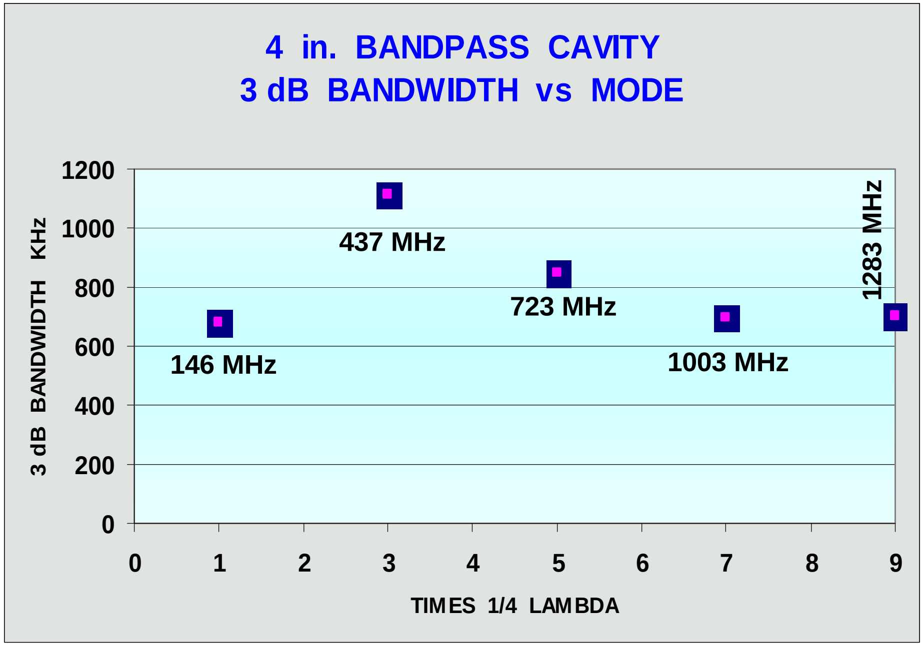




BANDPASS CAVITIES - OVERTONE OPERATION

- BANDPASS CAVITIES WILL OPERATE AT ODD MULTIPLES OF THEIR FUNDAMENTAL FREQUENCY
- OPERATION AT 3X and 5X THE FUNDAMENTAL FREQUENCY PROVIDES LOW LOSSES AND A HIGHER Qu FACTOR



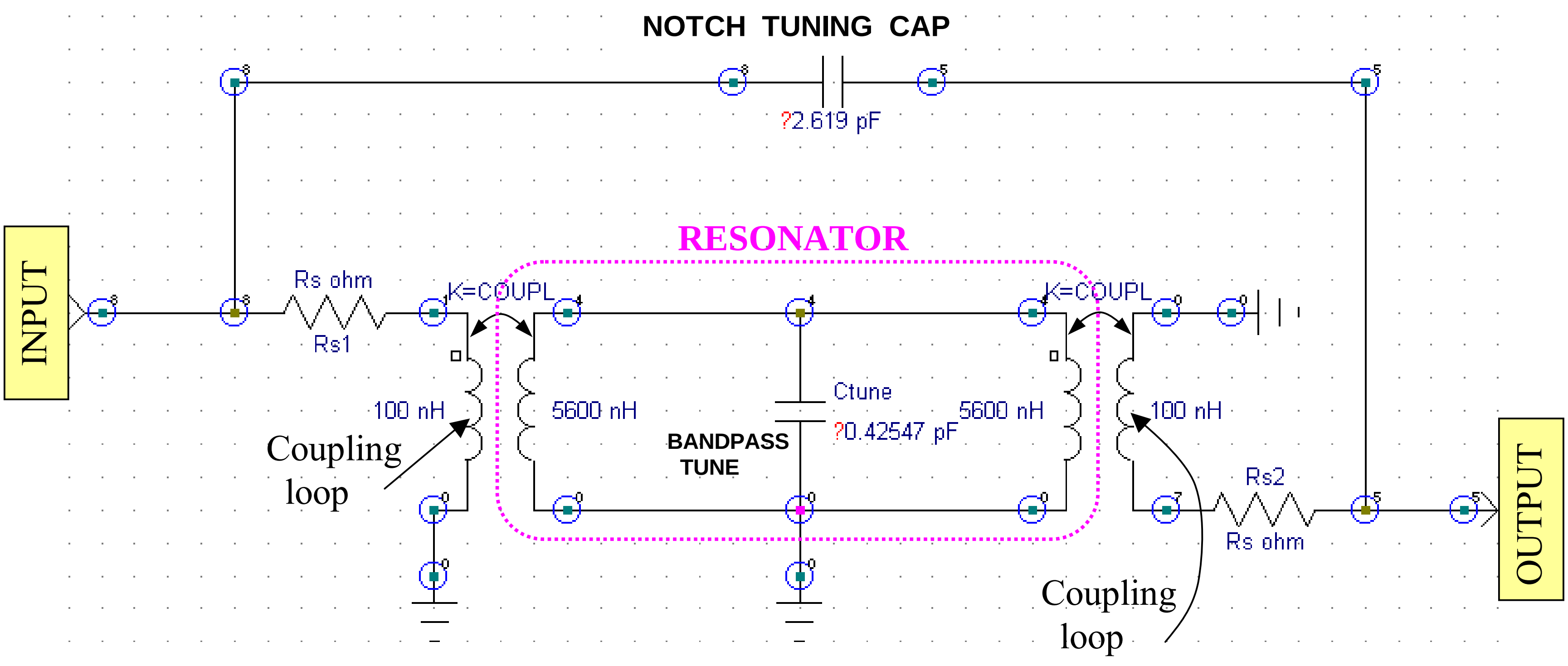


NOTCH – BANDPASS CAVITIES

- ❑ LO PASS – HI PASS FILTERS
- ❑ BANDPASS CAVITIES
- ❑ NOTCH – BANDPASS CAVITIES
  - ❑ TWO LOOP CAVITIES (modified bandpass)
  - ❑ SERIES RESONANT LOOP
  - ❑ PARALLEL RESONANT LOOP (Q circuit)

TWO LOOP CAVITIES (modified bandpass)

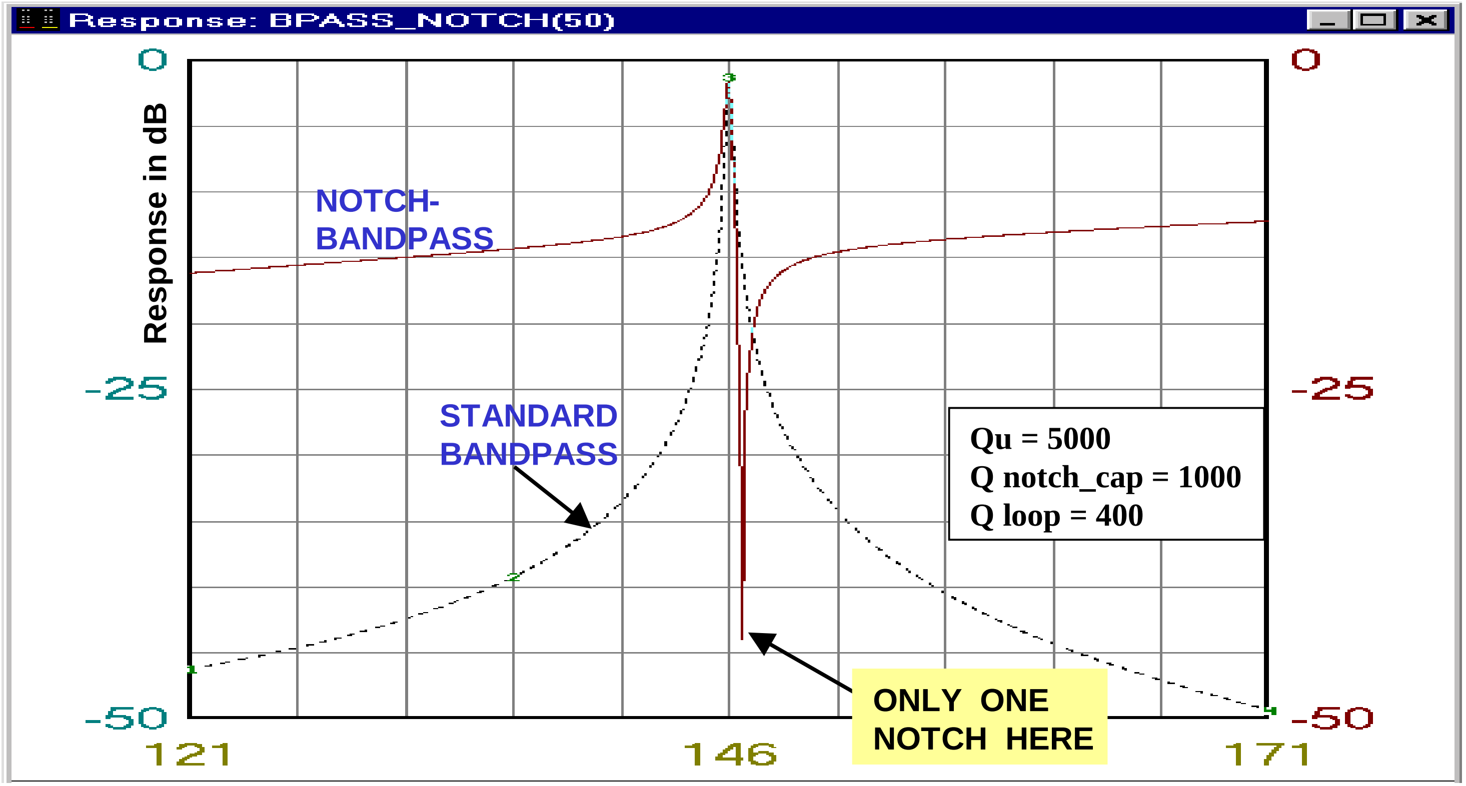
- A LOW VALUE CAPACITOR IS ADDED BETWEEN INPUT AND OUTPUT
- GENERATES A TRANSMISSION NOTCH ABOVE BANDPASS
- AN INDUCTOR WILL SET THE NOTCH BELOW THE BANDPASS



EQUIVALENT CIRCUIT

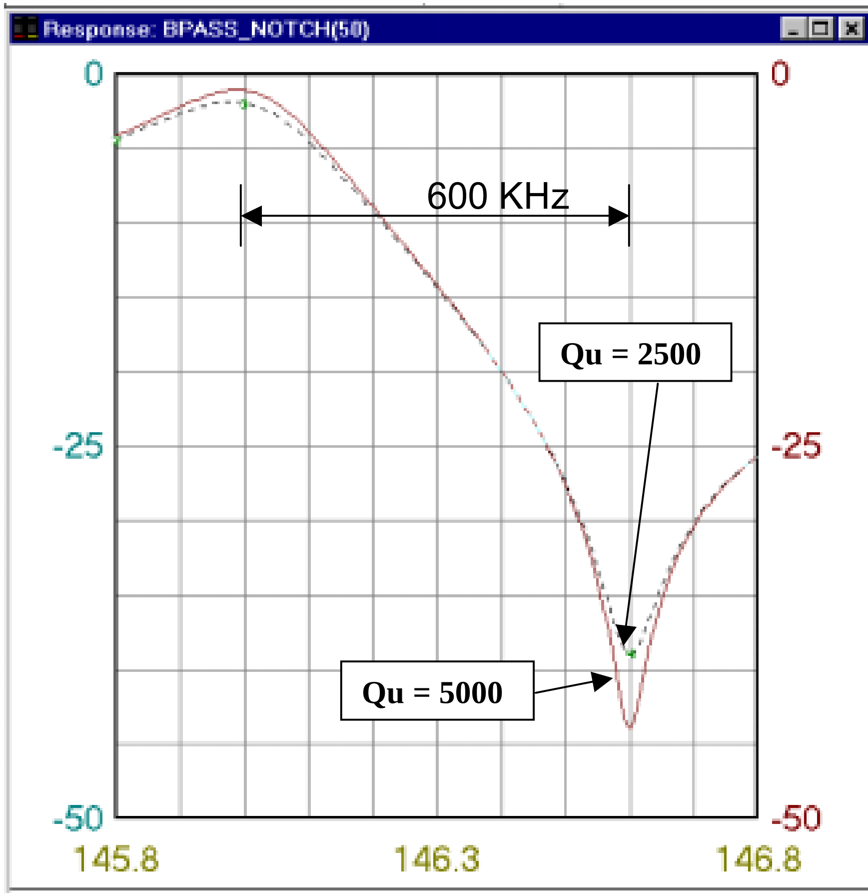
TWO LOOP CAVITIES (modified bandpass)

- SERIES CAPACITOR BETWEEN INPUT AND OUTPUT (~ 3 pF) GIVES THE DESIRED NOTCH-BANDPASS CHARACTERISTIC – ALLOWS NOTCH TUNING
- SERIES CAPACITOR TUNING SENSITIVITY: ~ - 20 % PER 100 KHz (146 MHz) (REDUCING C MOVES THE NOTCH UP IN FREQUENCY)
- BANDPASS LOSS ~ UNCHANGED – COMPARED TO STANDARD BANDPASS

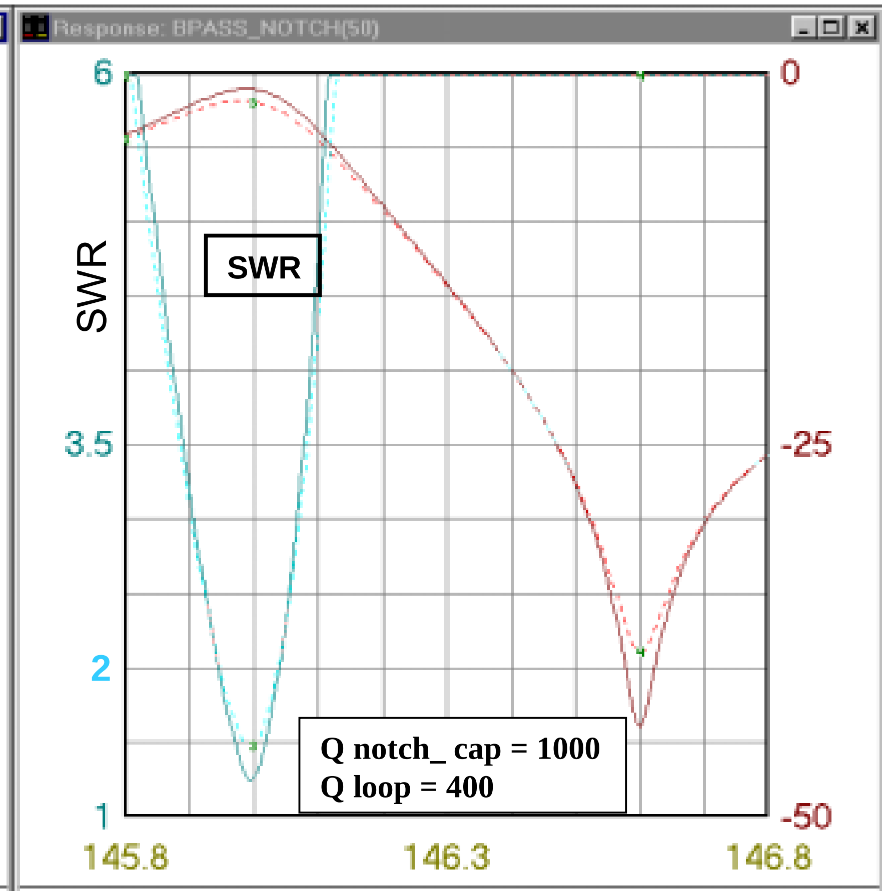


TWO LOOP CAVITIES (modified bandpass)

- ❑ REDUCING Qu FROM 5000 TO 2500 REDUCES THE NOTCH BY ~ 5 dB AND ADDS ~ 1 dB LOSS IN THE BANDPASS
- ❑ THE BANDPASS CENTER HAS LOWEST SWR - ALWAYS



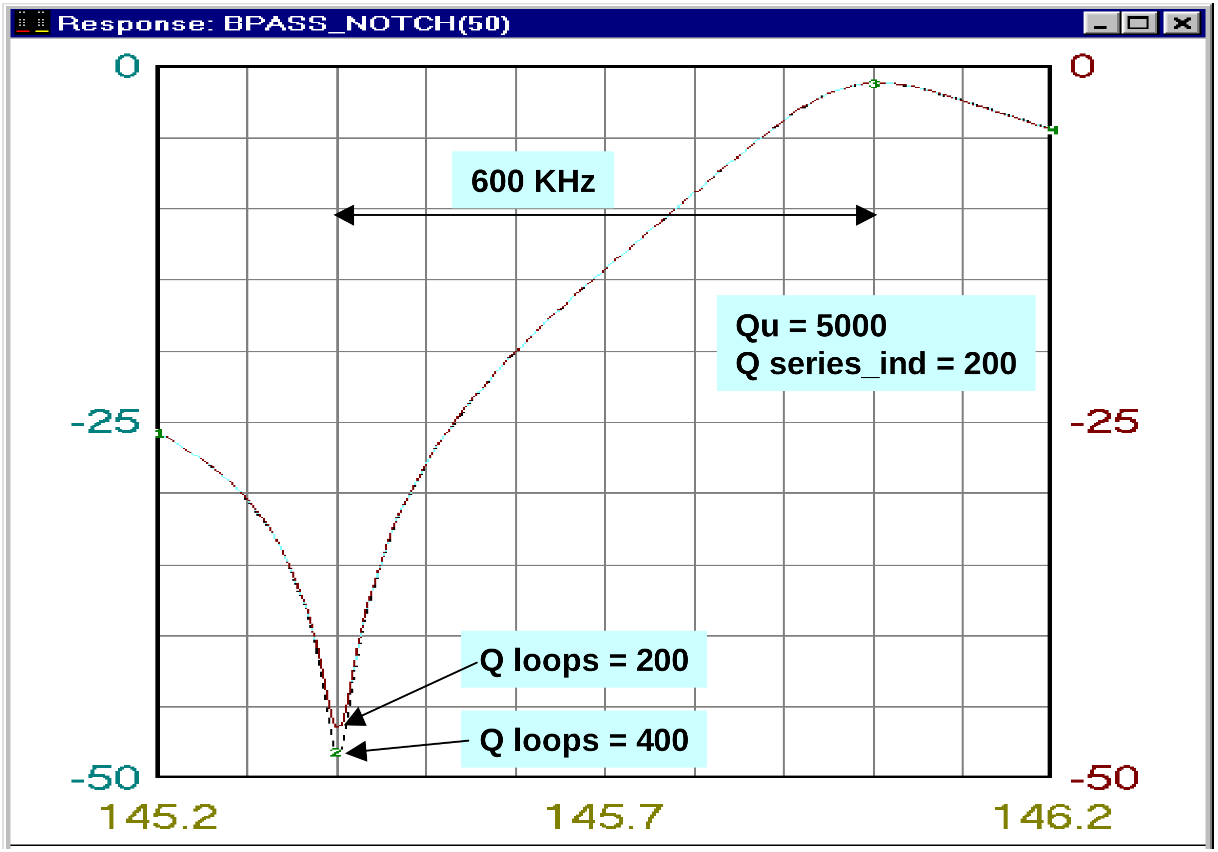
EFFECT OF CAVITY Q (Qu)



THE SWR CURVE DEFINES THE EXACT BANDPASS FREQUENCY

TWO LOOP CAVITIES (modified bandpass)

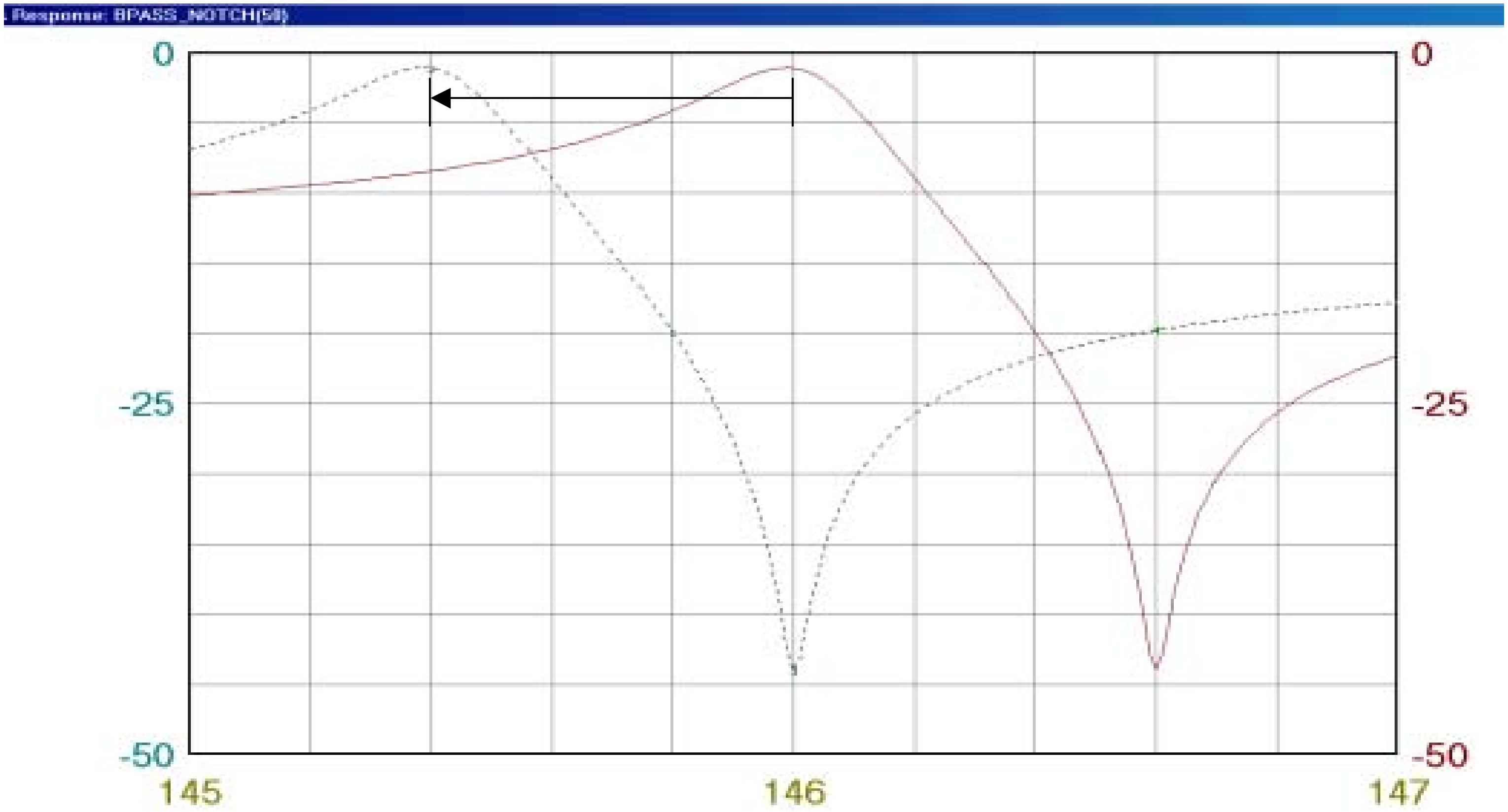
- SETTING THE NOTCH BELOW THE BANDPASS REQUIRES REPLACING THE SERIES CAP BY A SERIES INDUCTOR (~ 400 nH)
- REDUCING THE Q FACTOR OF THE LOOPS FROM 400 TO 200 DEGRADES THE NOTCH DEPTH BY ~ 3 dB



SETTING THE NOTCH BELOW THE BANDPASS

TWO LOOP CAVITIES (modified bandpass)

- INCREASING THE RESONATOR LENGTH MOVES THE BANDPASS FREQUENCY DOWN
- SHIFTING THE BANDPASS FREQUENCY DOWN ALSO SHIFTS THE NOTCH FREQUENCY BY APPROXIMATELY THE SAME AMOUNT



MOVING THE BANDPASS FREQUENCY DOWN

NOTCH – BANDPASS
SERIES RESONANT LOOP CAVITIES

- ❑ TWO LOOP CAVITY (modified bandpass)
- ❑ SERIES RESONANT LOOP
- ❑ PARALLEL RESONANT LOOP (Q circuit)

SERIES RESONANT LOOP

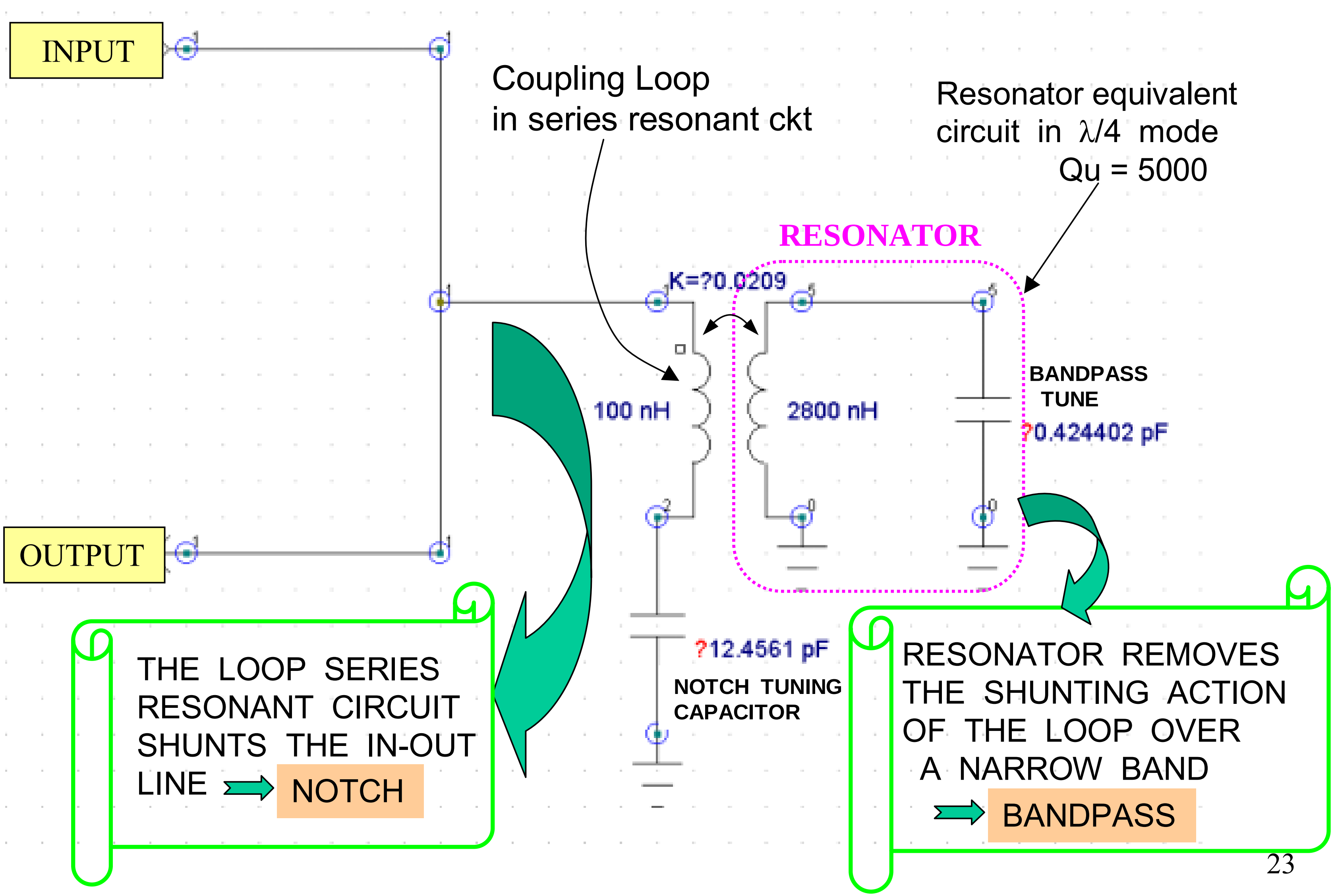
- ONLY ONE LOOP IS USED
- A SERIES CAPACITOR ADJUSTS THE NOTCH FREQUENCY ABOVE AND BELOW THE BANDPASS

A SINGLE CONNECTOR WITH AN EXTERNAL TEE WILL WORK AS WELL

HOME MADE 4 in. CAVITY WITH SERIES CAPACITOR

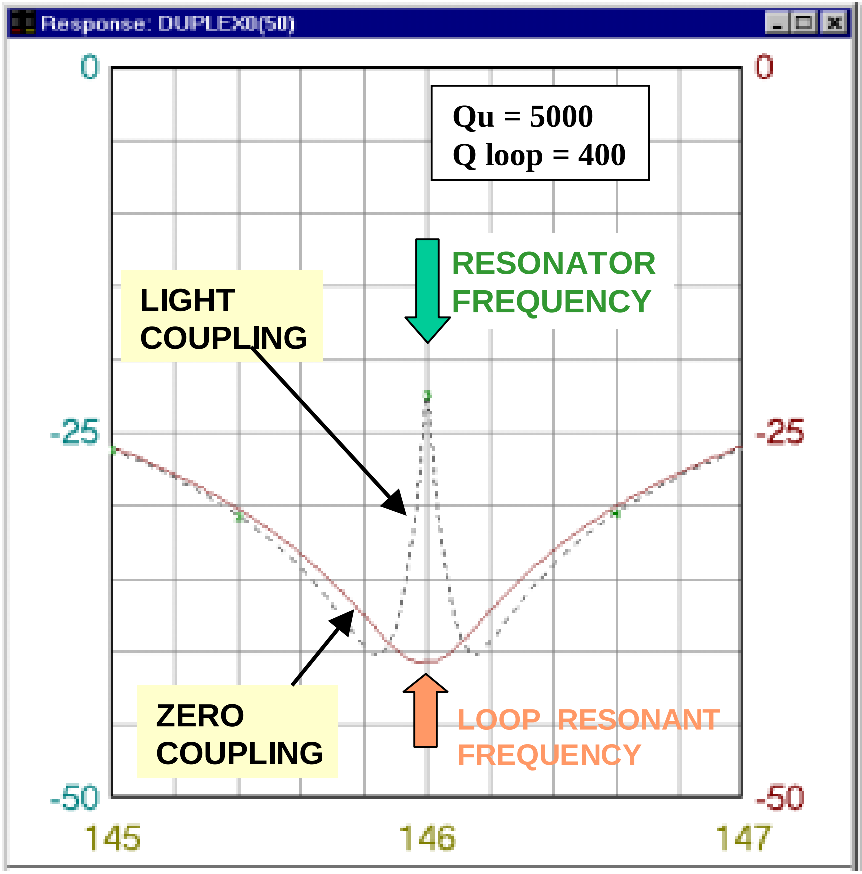
SERIES RESONANT LOOP

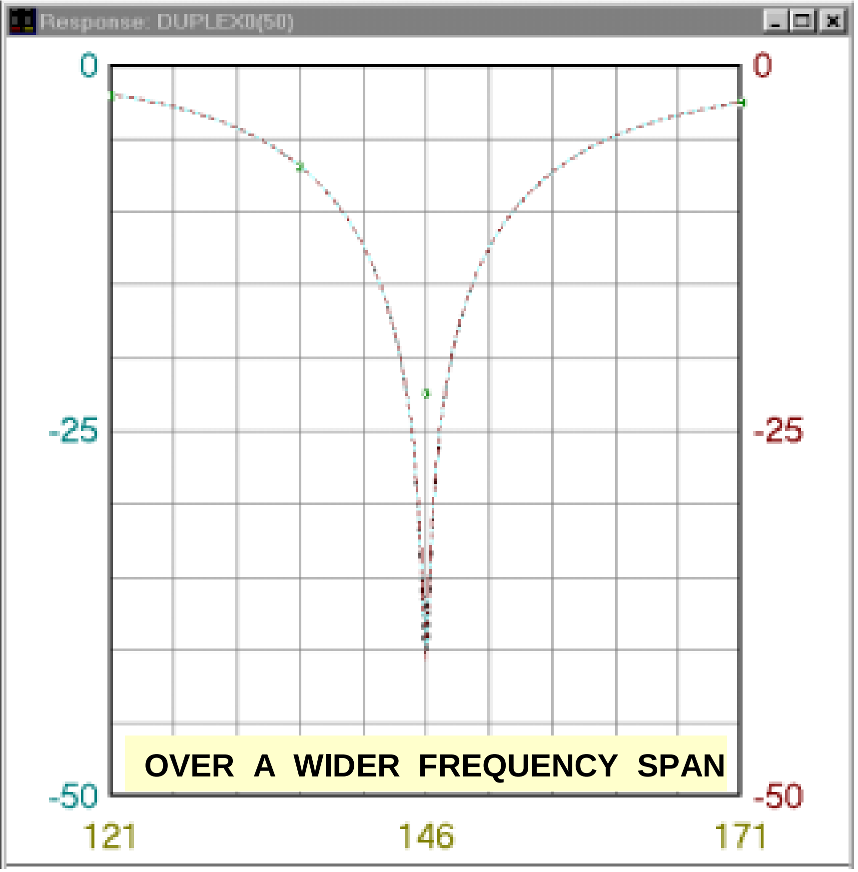
GIVES NOTCH – BANDPASS RESPONSE



SERIES RESONANT LOOP

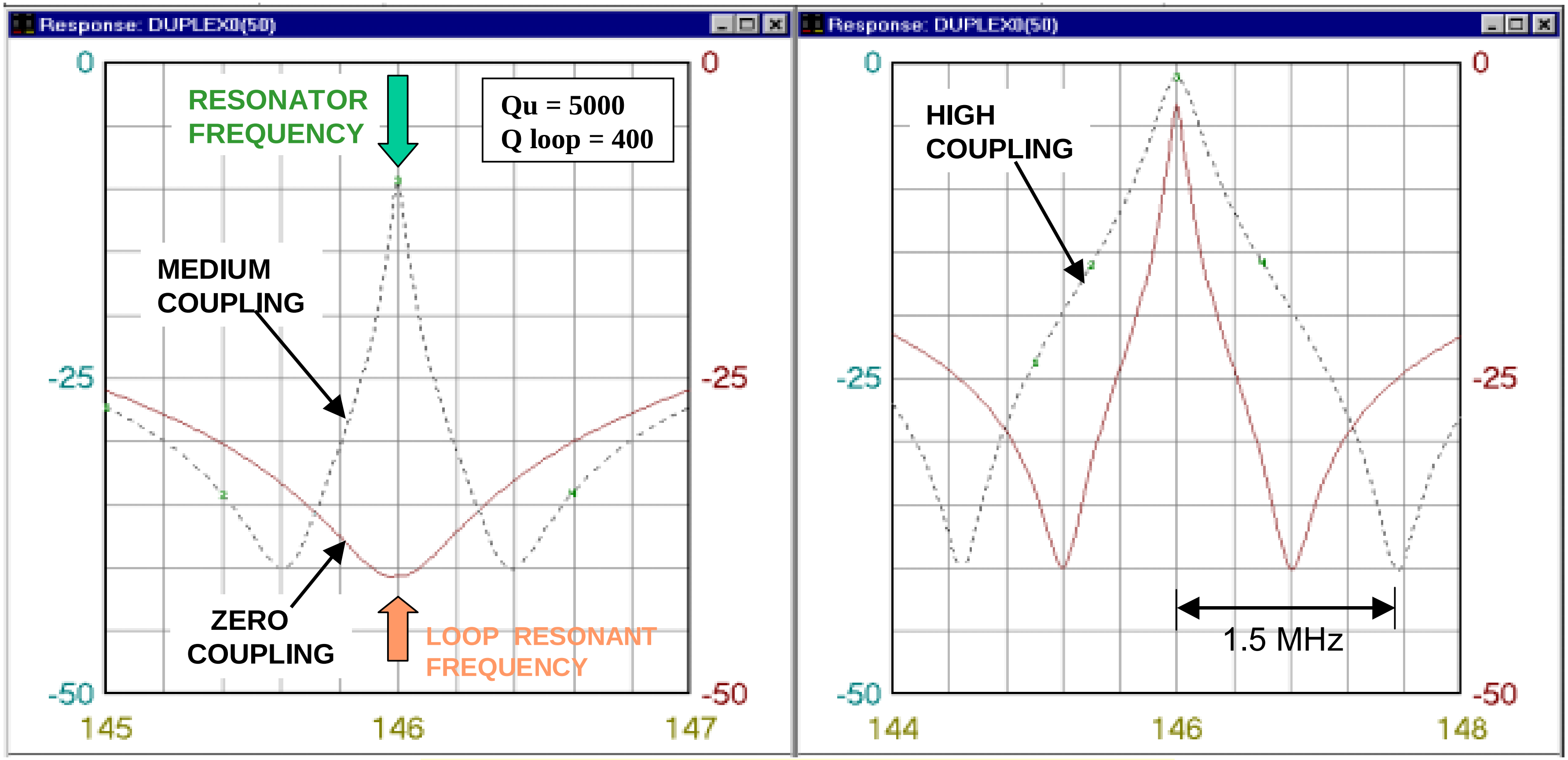
- THE COUPLING LOOP IS INITIALLY UNCOUPLED FROM THE RESONATOR
- SERIES CIRCUIT GIVES MAXIMUM ATTENUATION AT SERIES RESONANCE
- THE RESONATOR IS TUNED AT THE SAME FREQUENCY
- NOTCH DEPTH IS A FUNCTION OF THE Q OF THE LOOP





SERIES RESONANT LOOP

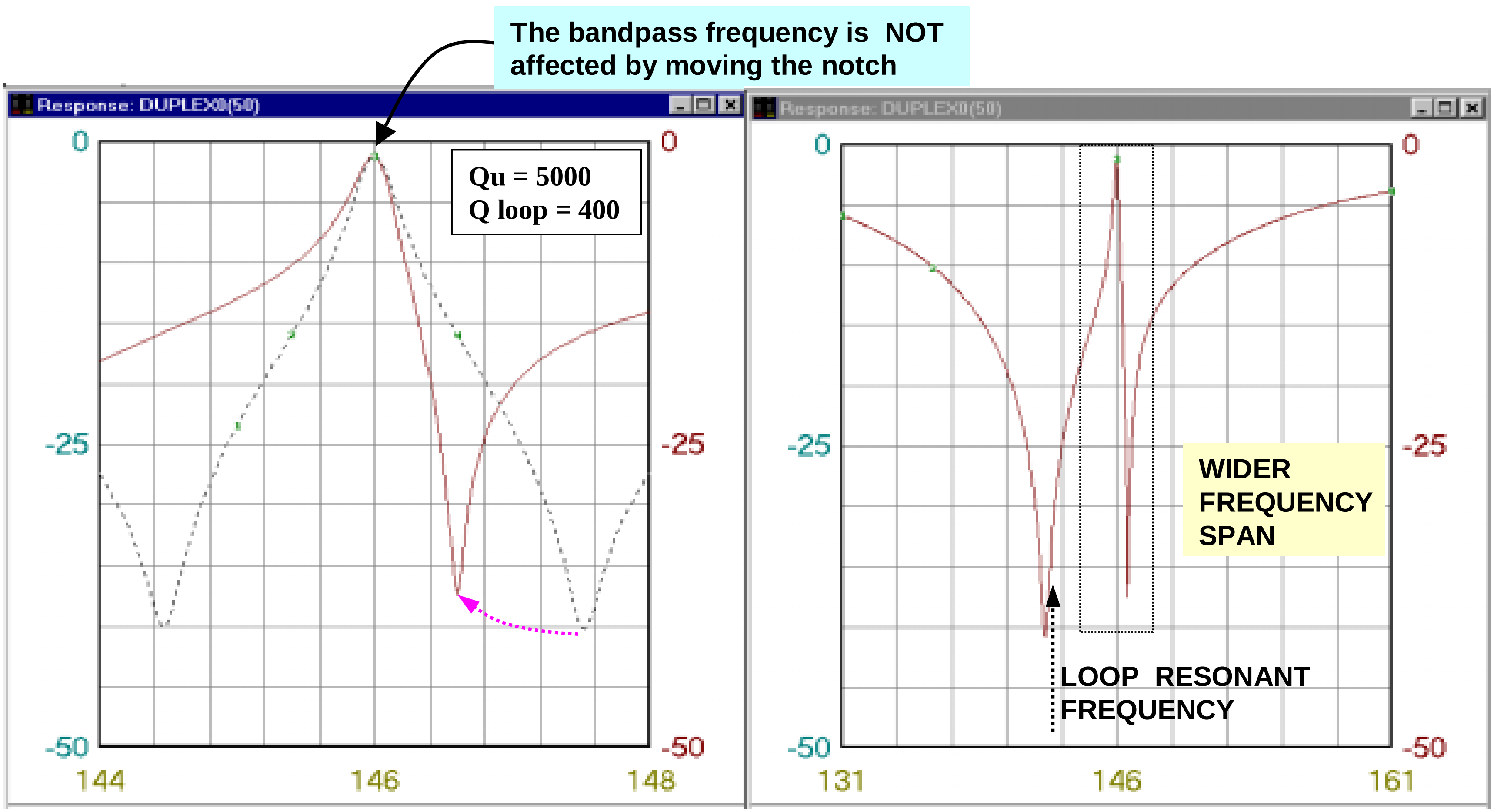
- INCREASING THE COUPLING SPREADS THE TWO NOTCHES APART AND…
- DECREASES THE INSERTION LOSS AT THE BANDPASS FREQUENCY
- FOR 1 dB LOSS THE NOTCHES ARE AT +/- 1.5 MHz – NEED TO SHIFT



EFFECT OF CHANGING THE LOOP COUPLING

SERIES RESONANT LOOP

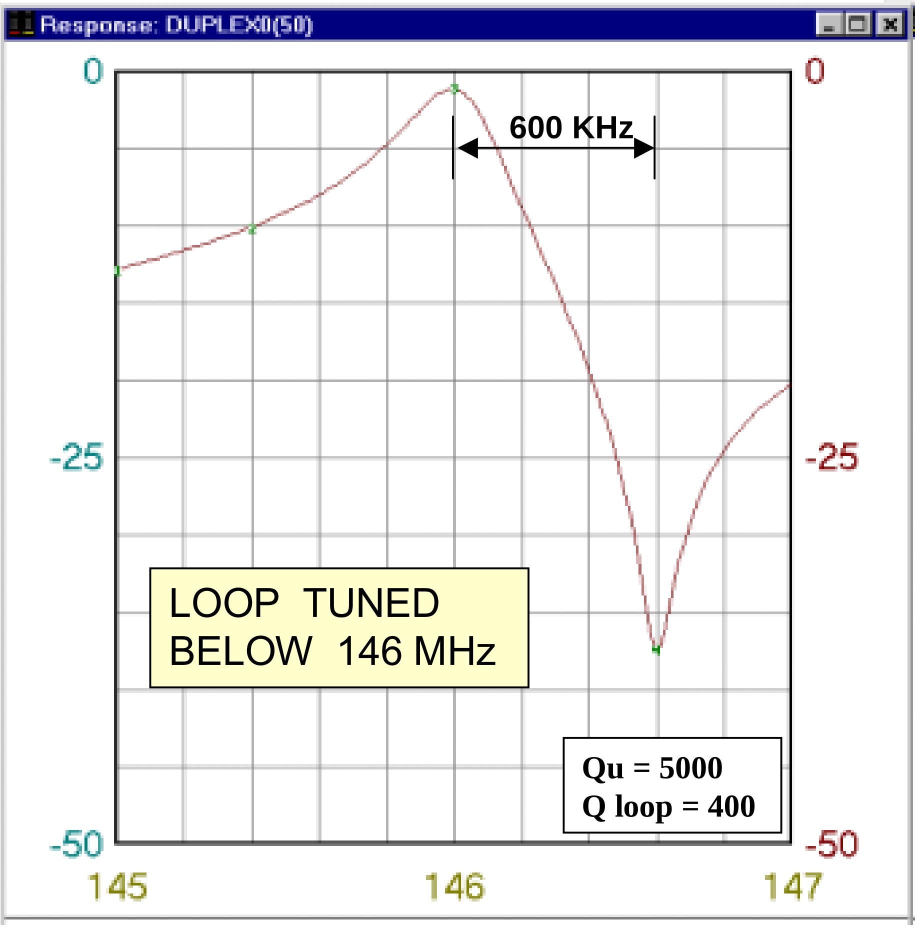
- THE UPPER NOTCH FREQUENCY IS SHIFTED DOWN BY LOWERING THE LOOP RESONANT FREQUENCY (BROWN CURVES)
- THE DEPTH OF THE UPPER NOTCH SUFFERS

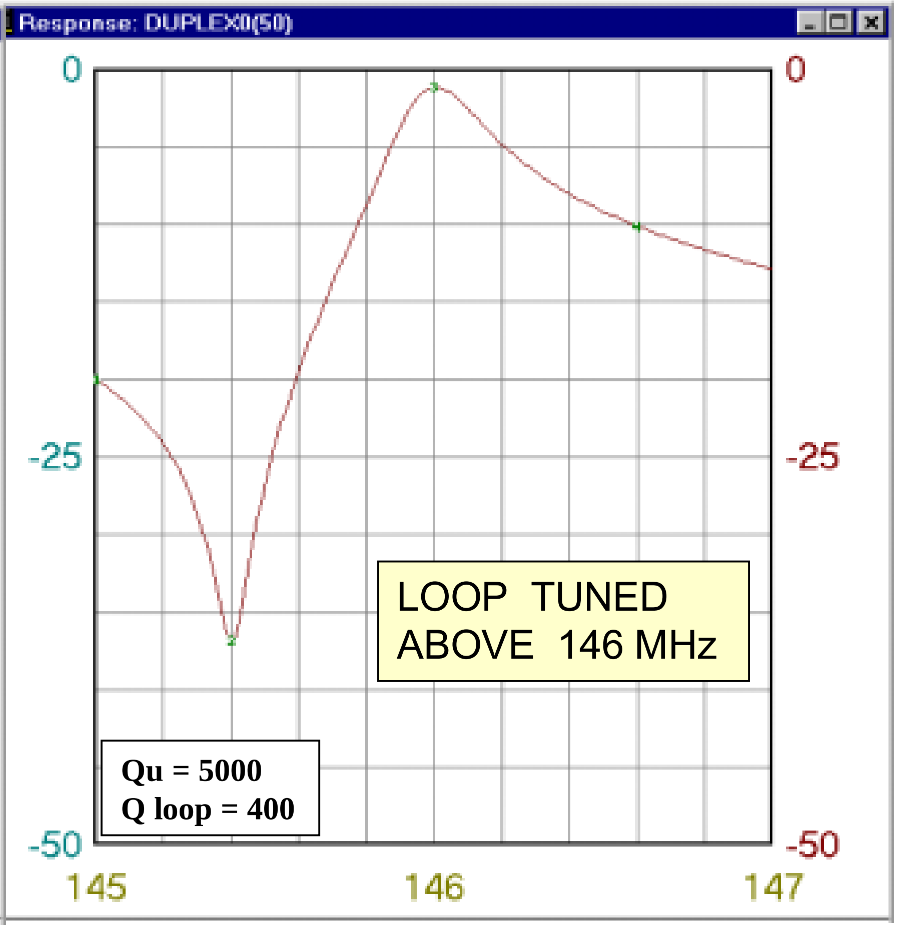


SHIFTING DOWN THE NOTCH FREQUENCY

SERIES RESONANT LOOP

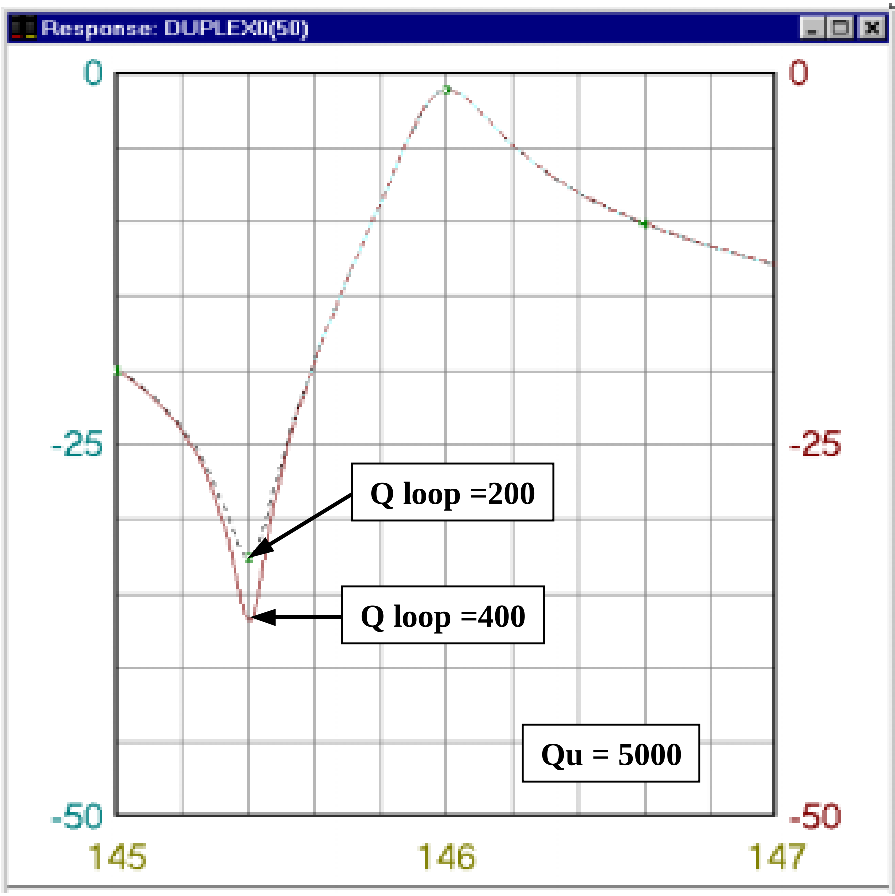
- ❑ TUNING THE LOOP BELOW AND ABOVE THE BANDPASS FREQUENCY WILL SET THE NOTCH +/- 600 KHz

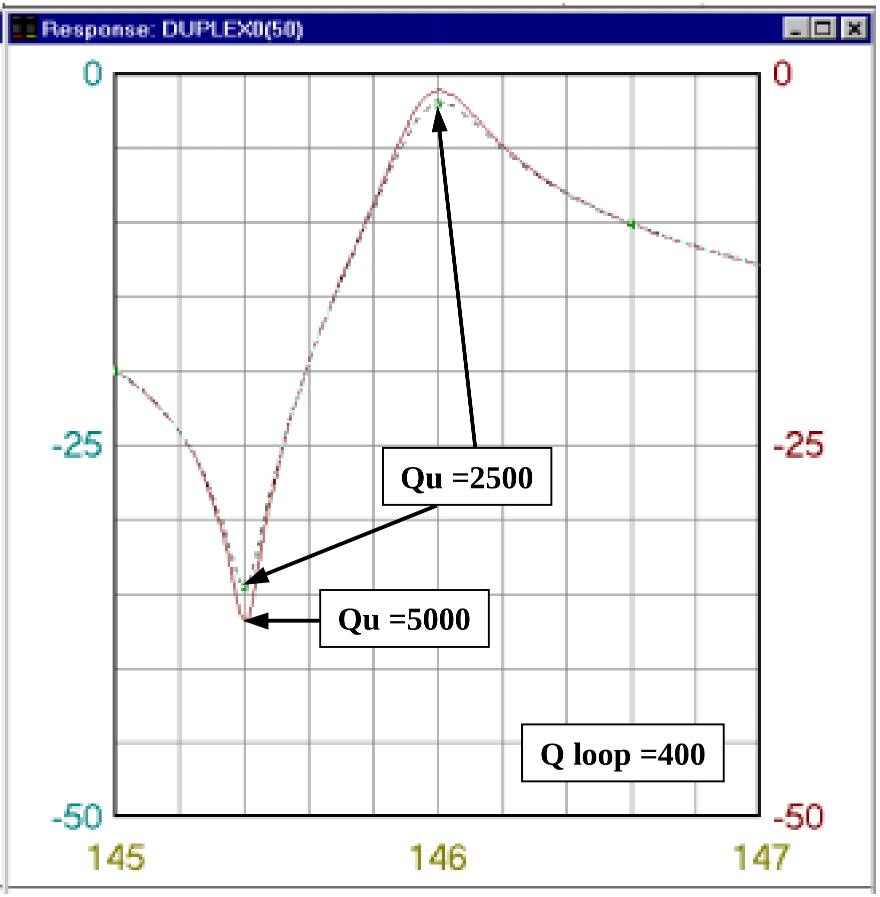




SERIES RESONANT LOOP

- THE Q OF THE LOOP SETS THE NOTCH DEPTH
- THE Q OF THE CAVITY (Qu) AFFECTS BOTH THE BANDPASS LOSS AND THE NOTCH DEPTH



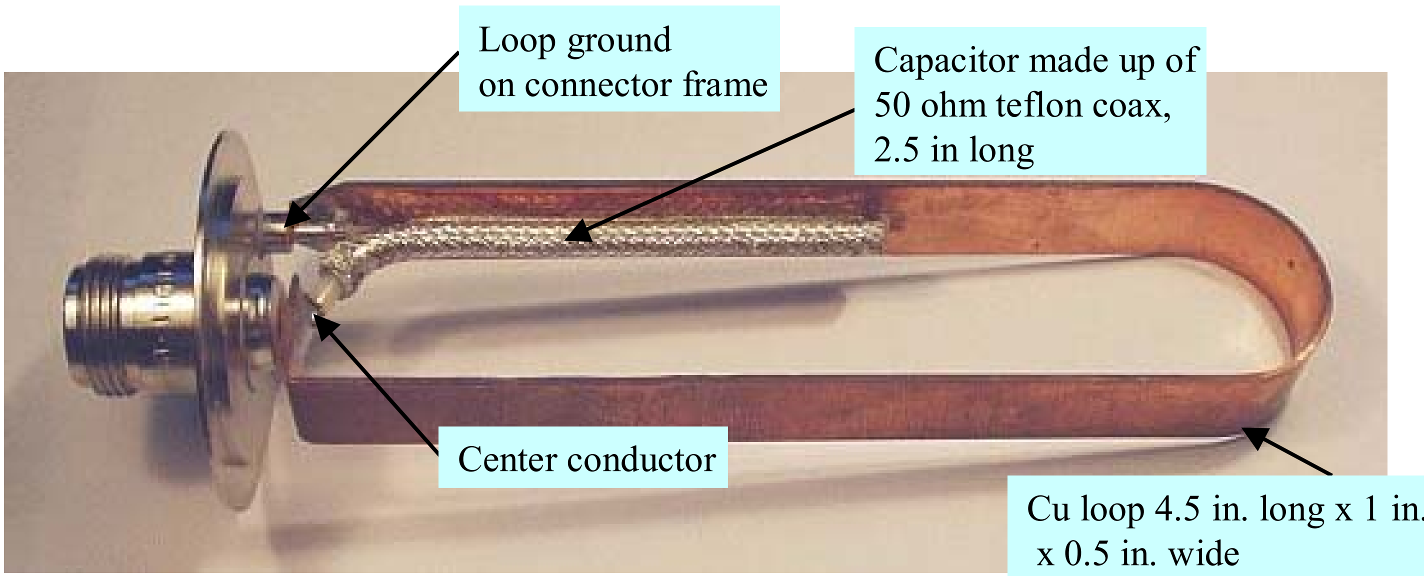


NOTCH – BANDPASS MODE
PARALLEL RESONANT LOOP CAVITIES

- TWO LOOP CAVITY (modified bandpass)
- SERIES RESONANT LOOP
- ➡ PARALLEL RESONANT LOOP (Q circuit)

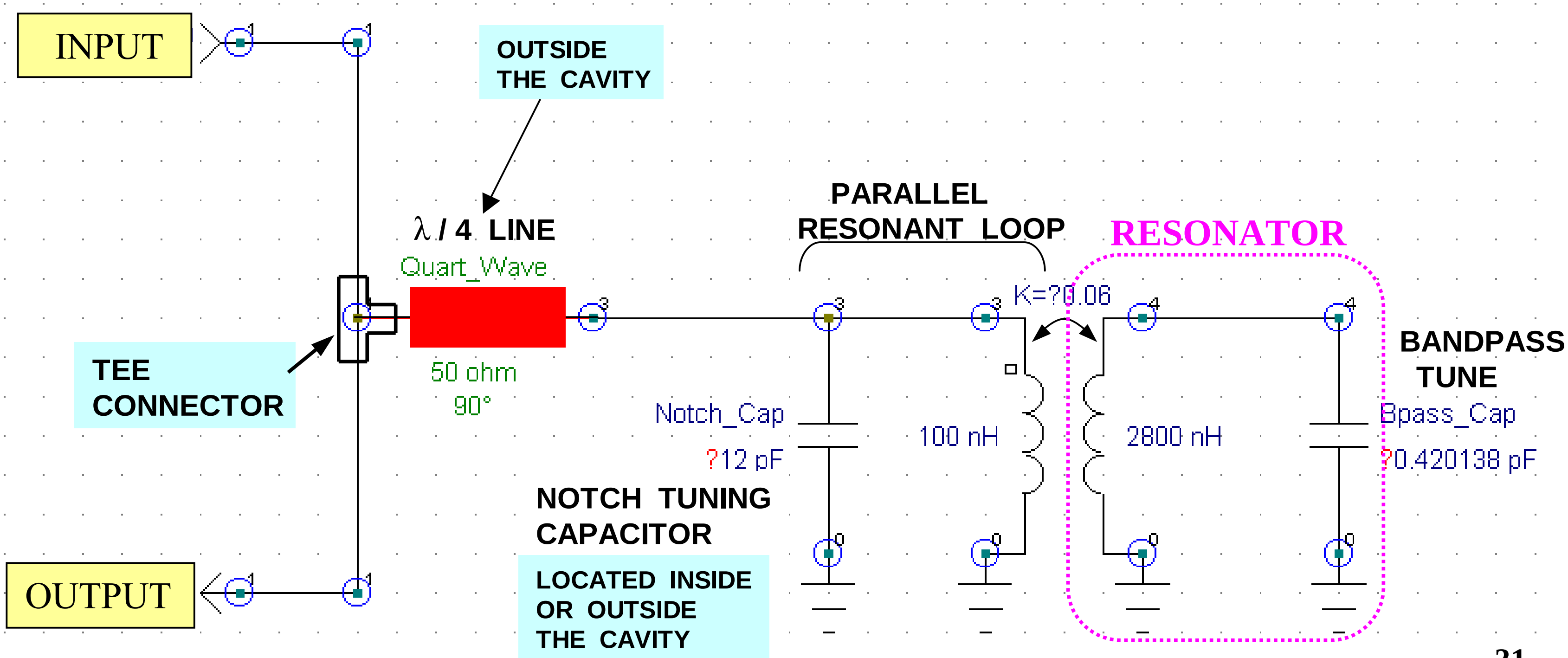
PARALLEL RESONANT LOOP (Q circuit)

- EXAMPLE OF A PARALLEL RESONANT LOOP
- HERE THE CAPACITOR IS MADE WITH A SHORT LENGTH OF COAX



PARALLEL RESONANT LOOP (Q circuit)

- A QUARTER WAVELENGTH LINE TRANSFORMS THE LOOP PARALLEL CIRCUIT INTO A SERIES CIRCUIT – EFFECTIVELY
- OPERATION IS SIMILAR TO THE SERIES RESONANT LOOP
- TWO NOTCHES ARE ALWAYS PRESENT WITH THIS CONFIGURATION

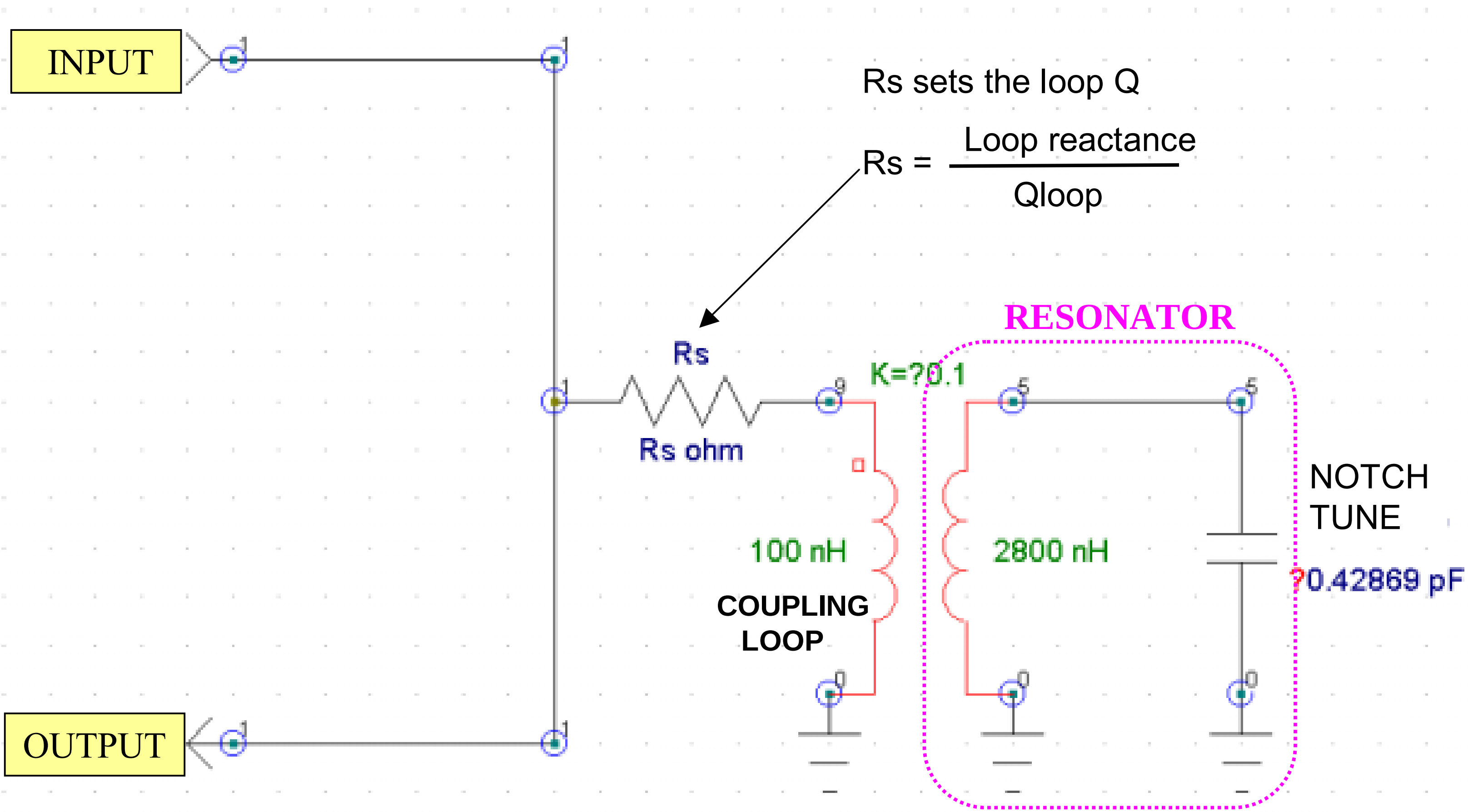


NOTCH CAVITIES

- ❑ CAVITY NOTCHERS
- ❑ HELIAX NOTCHERS

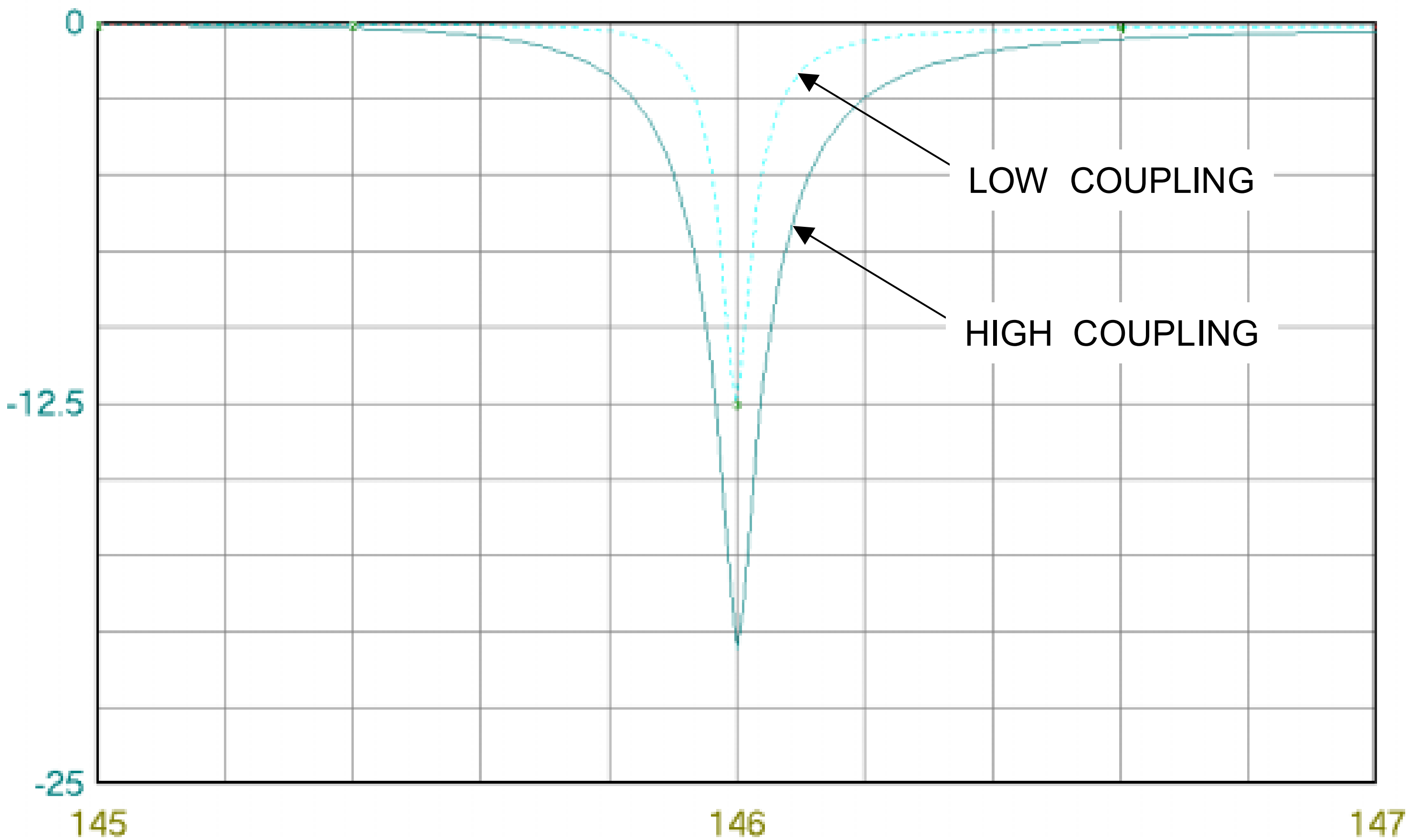
CAVITY NOTCHER for 146 MHz

EQUIVALENT CIRCUIT



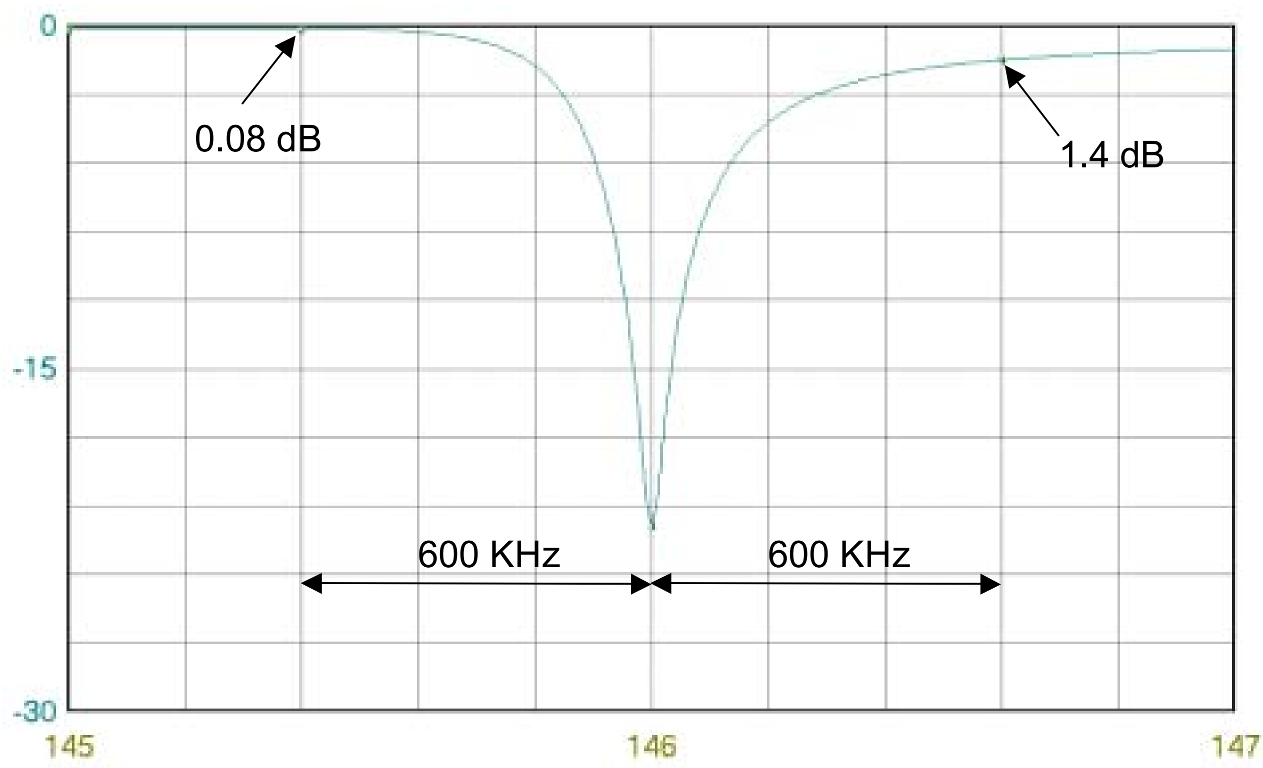
CAVITY NOTCHER FREQUENCY RESPONSE

- ❑ VARYING THE LOOP COUPLING AFFECTS THE NOTCH DEPTH AND
- ❑ DETUNES THE NOTCH FREQUENCY SOMEWHAT



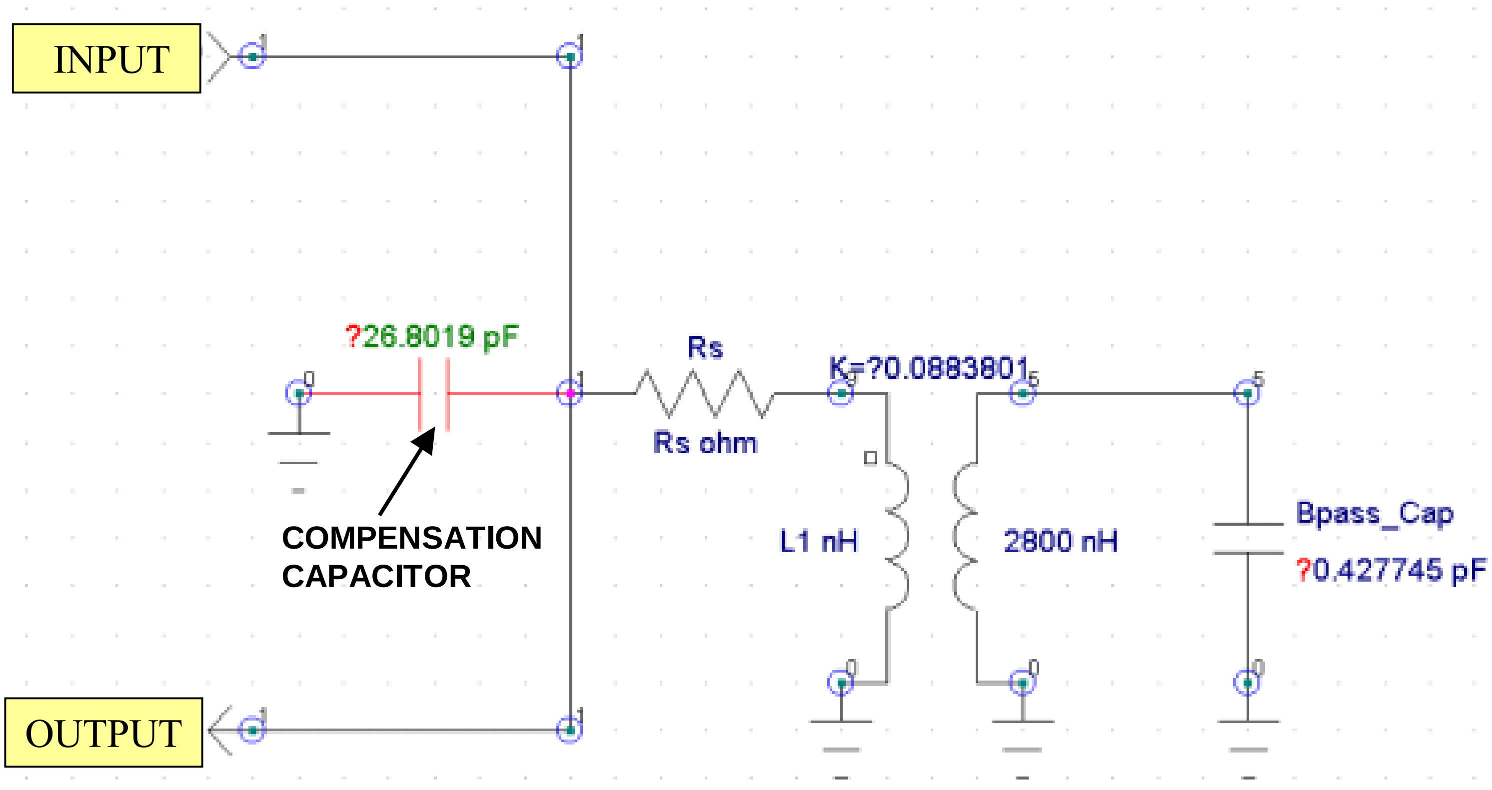
CAVITY NOTCHER FREQUENCY RESPONSE

- RESPONSE NOT SYMETRICAL AT +/- 600 KHz
- HIGH SIDE HAS A LOT MORE ATTENUATION AT + 600KHz



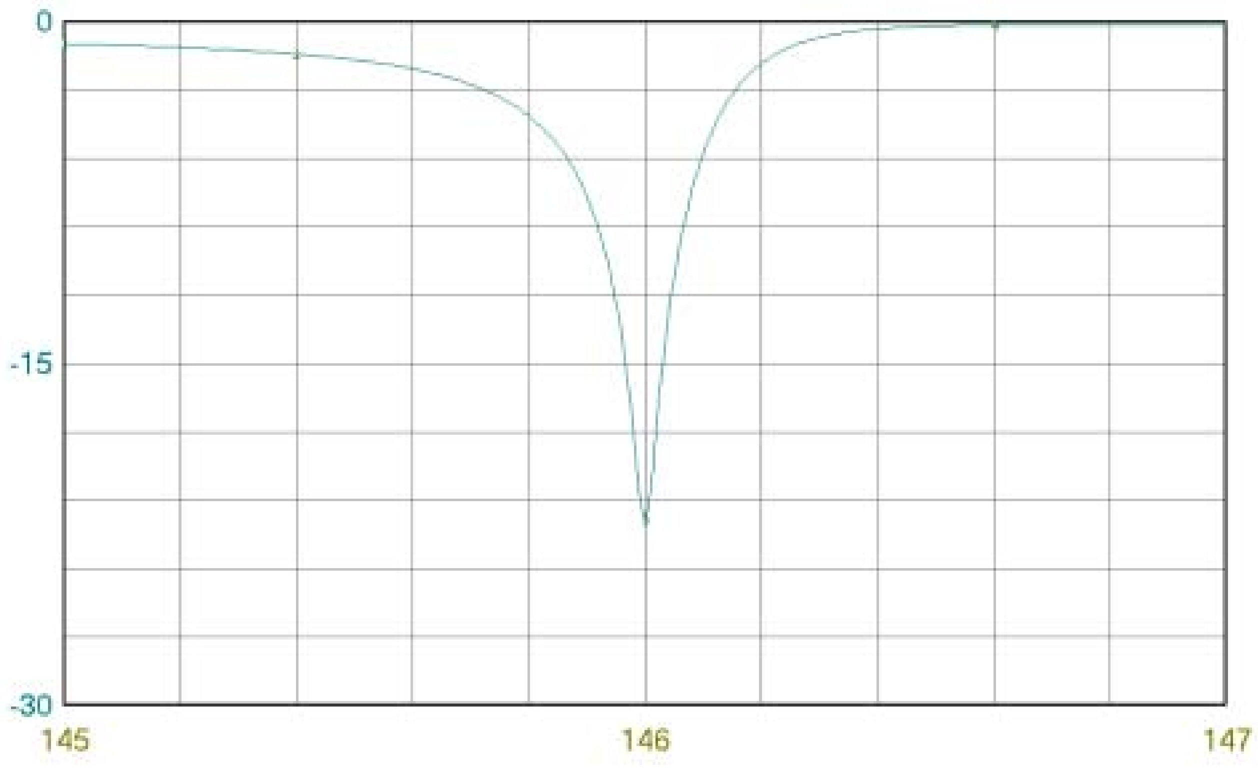
CAVITY NOTCHER WITH COMPENSATION CAPACITOR

- ADDING A COMPENSATION CAPACITOR DECREASES THE LOSSES ON THE UPPER SIDE
- THE COMPENSATION CAPACITOR HAS AN OPTIMUM VALUE FOR A GIVEN SPLIT
- ITS Q FACTOR IS NOT CRITICAL - AN OPEN COAX STUB MAY BE USED



CAVITY NOTCHER WITH COMPENSATION CAPACITOR

- ❑ CONSIDERABLY REDUCED HIGH SIDE INSERTION LOSS
- ❑ LOW SIDE NOW HAS THE HIGH INSERTION LOSS



CAVITY NOTCHERS - GENERAL

- OBTAINING THE DEEPEST NOTCH REQUIRES:
  INCREASING THE LOOP COUPLING
  DECREASING THE LOOP INDUCTANCE
- THESE TWO REQUIREMENTS ARE CONTRADICTORY SINCE
  A LOW INDUCTANCE LOOP WILL HAVE LESS COUPLING AND VICE VERSA
- IT MAY BE DIFFICULT TO GET 30 dB REJECTION ON A 6 in. CAVITY
- THE LOW SIDE MAY HAVE TO BE COMPENSATED WITH AN INDUCTOR
  TO ACHIEVE MINIMUM LOSSES (OR A SHORTED STUB)
- THE Q FACTOR OF THE LOOPS IS NOT CRITICAL, AS LONG AS $Q > 100$ OR SO
- THE NOTCH - BANDPASS MODE MAKES A MORE EFFICIENT USE OF THE CAVITY.
  NOTCH DEPTHS BETTER THAN 35 dB ARE EASILY OBTAINED WITH A 6 in. CAVITY

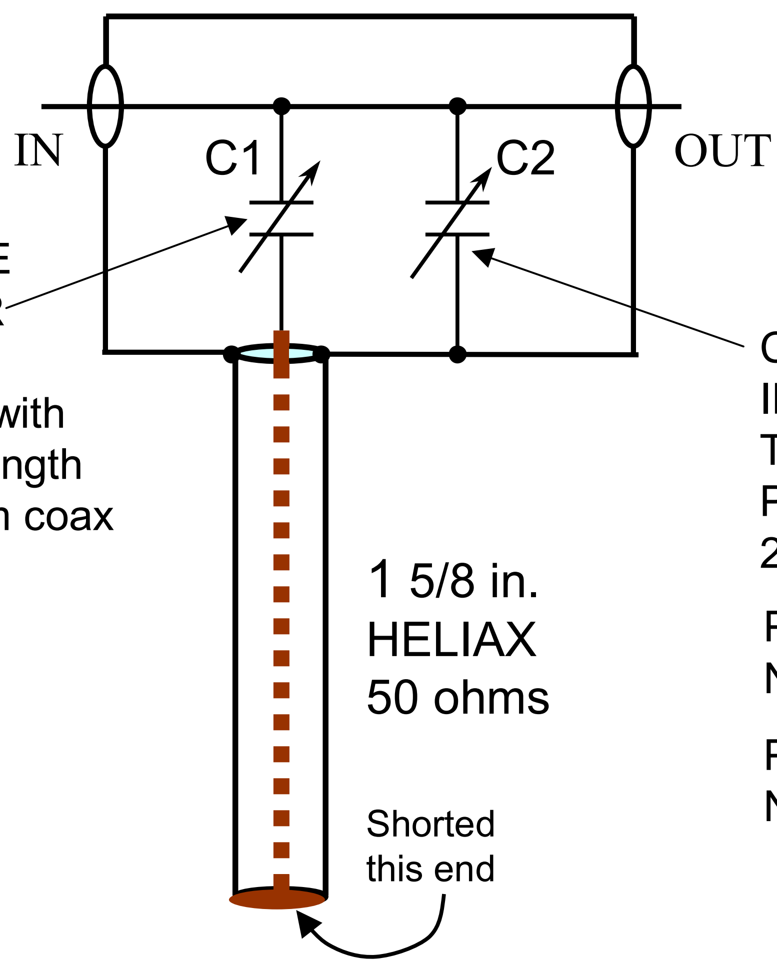
NOTCH CAVITIES

- ❑ CAVITY NOTCHERS
- ❑ HELIAX NOTCHERS

HELIAX NOTCHER for 146 MHz

- USES AN INDUCTIVE SHORTED STUB See ref. 3 and 4
- THE STUB EXHIBITS SERIES RESONANCE AT THE NOTCH FREQUENCY

HI VOLTAGE
CAPACITOR
1 – 3 pF
May be made with
a very short length
of RG-213 foam coax



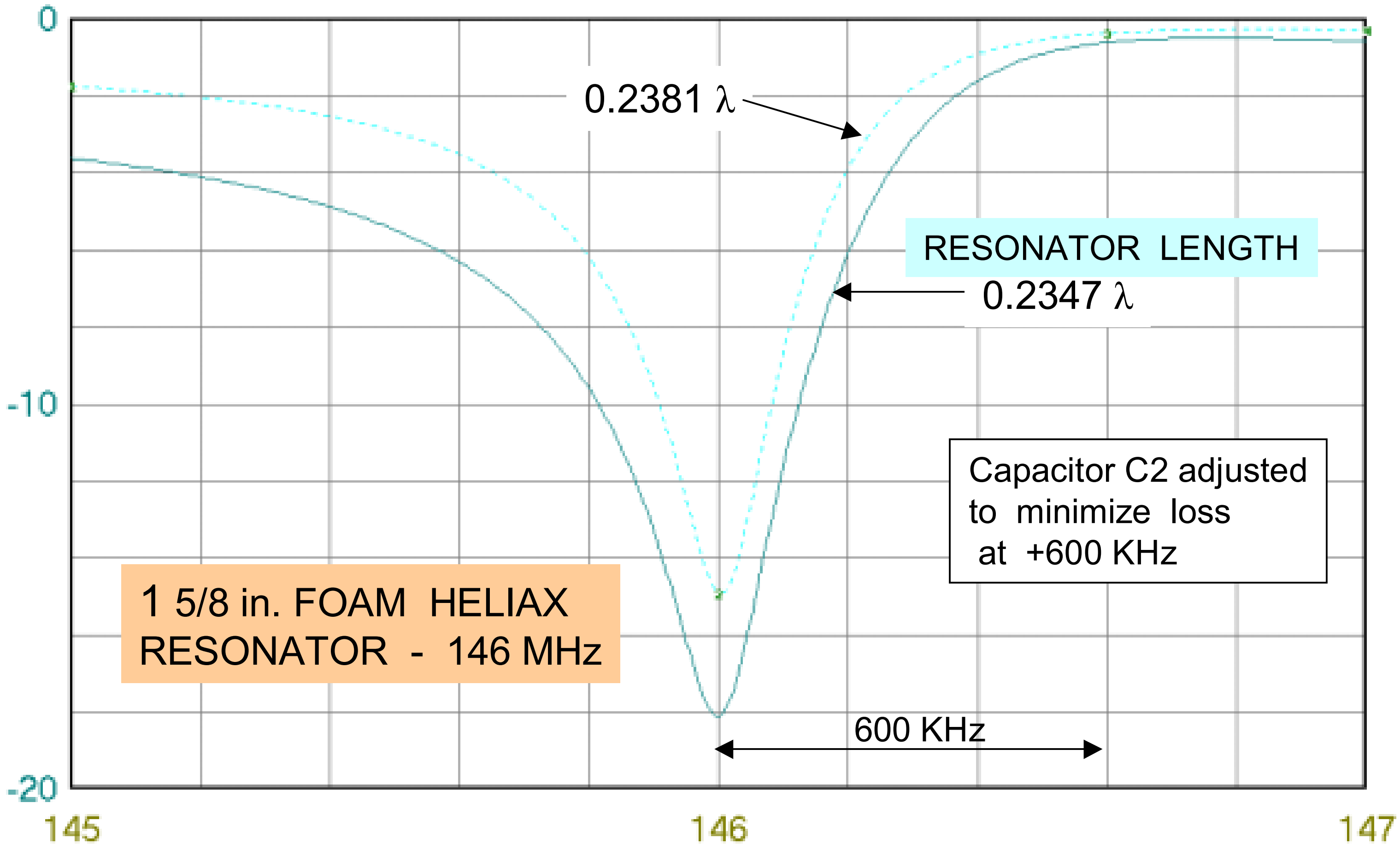
CAPACITOR OR
INDUCTOR
TO OPTIMIZE
PASSBAND LOSS
25 – 60 pF

PASSBAND ABOVE THE
NOTCH: use a **CAPACITOR**

PASSBAND BELOW THE
NOTCH: use an **INDUCTOR**

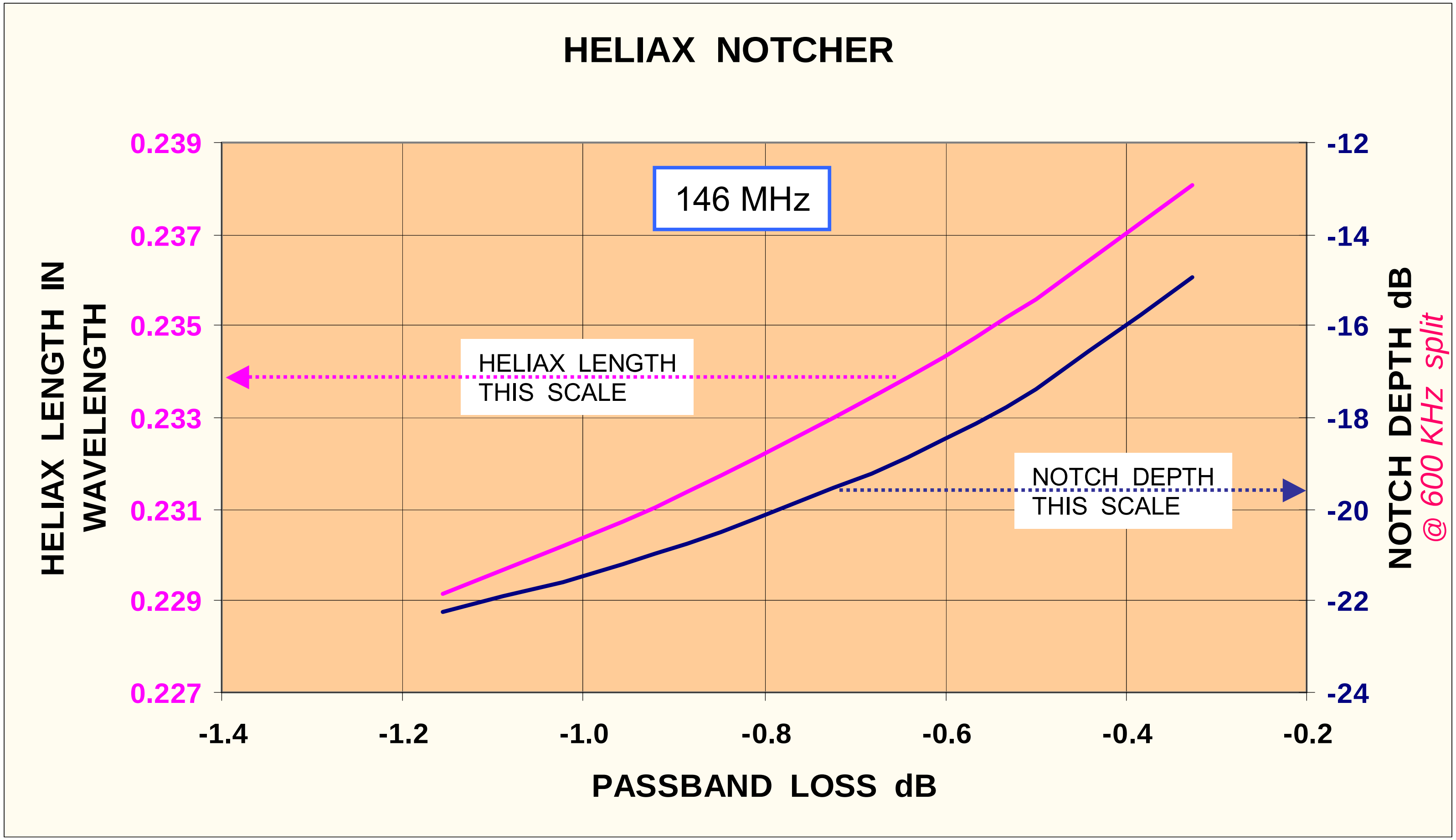
HELIAX NOTCHER - FREQUENCY RESPONSE

1 5/8 in. FOAM HELIAX Vf=0.87 50 ohms 0.156 dB/100 ft @ 50 MHz
Series cap = 50 ohm foam coax Vf=0.87 2.2 dB/100 ft @ 150 MHz



ATTENUATION AND LENGTH DATA FOR THE HELIAX NOTCHER

1 5/8 in. FOAM HELIAX Vf=0.87 50 ohms 0.156 dB/100 ft @ 50 MHz
Series cap = 50 ohm foam coax Vf=0.87 2.2 dB/100 ft @ 150 MHz



NOTE: Use with a λ/4 connecting line. The line adds ~ 5 dB to the notch depth

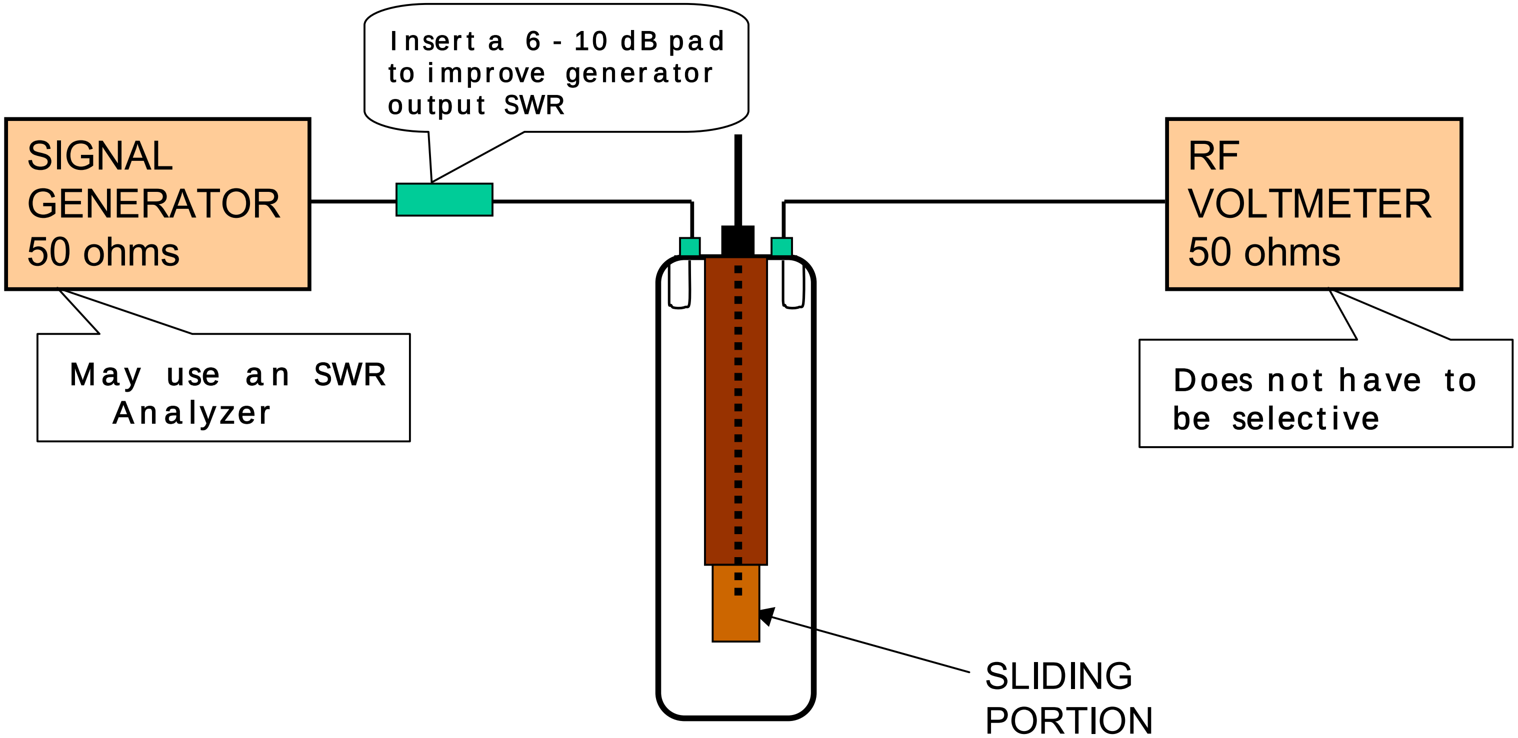
COMPARISONS

CAVITY TYPE	PLUS	MINUS
BANDPASS	• EASIEST TO ADJUST • INCREASING REJECTION OF OUTSIDE SIGNALS	• POOR REJECTION CLOSE TO BANDPASS (12-18 dB @ 600 KHz on 2m)
DUAL LOOP BANDPASS	• BEST NOTCH DEPTH ~ 45 dB typical 6” cavity • ONLY ONE NOTCH • NOTCH TUNE SENSITIVITY IS LOW: -20% / 100KHz	• FLOATING SERIES CAPACITOR • SERIES INDUCTOR DIFFICULT TO ADJUST • SOME REJECTION OUTSIDE BANDPASS
SERIES RESONANT LOOP	• EASY TO ADJUST VIA SER CAP OR COUPLING • GOOD NOTCH DEPTH ~ 37 dB typical 6” cavity	• TWO NOTCHES – MISLEADING • NOTCH TUNE SENSITIVITY IS HIGH: -1% / 100KHz • LOOP Q DETERMINES NOTCH DEPTH • LITTLE REJECTION OUTSIDE BANDPASS AND NOTCH
PARALLEL RESONANT LOOP (Q circuit)	• SAME AS SERIES RESONANT LOOP	• SAME AS SERIES RESONANT LOOP • QUARTER WAVELENGTH CABLE INTRODUCE ADDITIONAL LOSSES
NOTCH CAVITIES	• ATTENUATE A NARROW BAND OF FREQUENCIES • MAY BE BUILT USING HELIAX CABLE	• NOTCH DEPTH NOT AS GOOD AS IN NOTCH-BANDPASS DESIGNS • USE WITH BANDPASS CAVITIES TO PROVIDE REJECTION FAR FROM TX/RX

TUNING INDIVIDUAL CAVITIES

TUNING BANDPASS CAVITIES

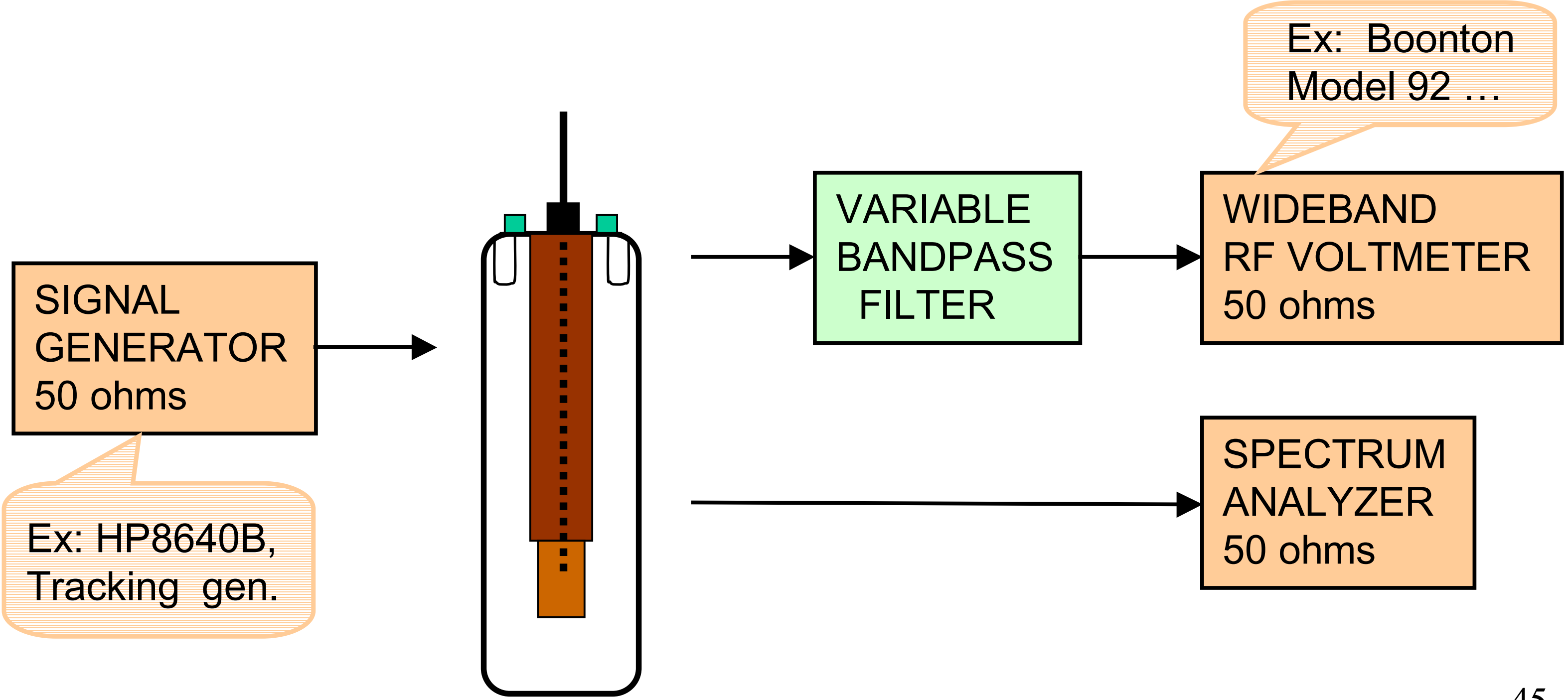
- ❑ ADJUST THE BANDPASS FREQUENCY FOR MAXIMUM SIGNAL
- ❑ CHECK THE INSERTION LOSS. CHANGE THE LOOP COUPLING IF REQ'D



TUNING NOTCH - BANDPASS CAVITIES

ABOUT THE VOLTMETER…

- ❑ WIDE BAND VOLTMETERS MAY PICK UP GENERATOR HARMONICS WHEN MEASURING <u>NOTCH DEPTH</u>
- ❑ A SELECTIVE VOLTMETER IS REQUIRED



TUNING NOTCH - BANDPASS CAVITIES

DUAL LOOP CAVITIES (MODIFIED BANDPASS TYPES)

- ADJUST THE BANDPASS FREQUENCY FOR MAXIMUM SIGNAL
- CHECK THE PASSBAND ATTENUATION AND ADJUST THE LOOP COUPLING AS REQUIRED (typically 0.3 TO 1.5 dB)
- TO INCREASE THE NOTCH FREQUENCY:

  DECREASE THE NOTCH CAPACITOR OR
  DECREASE THE NOTCH INDUCTOR
- NOTE THAT NOTCH DEPTH GETS WORSE AS THE NOTCH FREQUENCY GETS CLOSER TO THE BANDPASS PREQUENCY
- ADJUST THE BANDPASS FREQUENCY FOR LOWEST SWR
- RECHECK THE INSERTION LOSS AT THE BANDPASS FREQUENCY
- RECHECK THE NOTCH FREQUENCY AND DEPTH

TUNING NOTCH - BANDPASS CAVITIES

SERIES OR PARALLEL LOOP CAVITIES

- ❑ ADJUST THE BANDPASS FREQUENCY FOR MAXIMUM SIGNAL

- ❑ CHECK THE PASSBAND ATTENUATION AND ADJUST THE LOOP COUPLING AS REQUIRED (typically 0.3 TO 1.5 dB)

- ❑ TO INCREASE THE NOTCH FREQUENCY:

  UPPER NOTCH - ABOVE BANDPASS:

  DECREASE THE NOTCH CAPACITOR OR INCREASE COUPLING

  LOWER NOTCH - BELOW BANDPASS:

  DECREASE THE NOTCH CAPACITOR OR DECREASE COUPLING

- ❑ NOTE THAT NOTCH DEPTH GETS WORSE AS THE NOTCH FREQUENCY GETS CLOSER TO THE BANDPASS PREQUENCY

- ❑ ADJUST THE BANDPASS FREQUENCY FOR LOWEST SWR

- ❑ RECHECK THE INSERTION LOSS AT THE BANDPASS FREQUENCY

- ❑ RECHECK THE NOTCH FREQUENCY AND DEPTH

NOTCH - BANDPASS CAVITIES

LOOP RESONANCE VERIFICATIONS - SERIES OR PARALLEL LOOPS

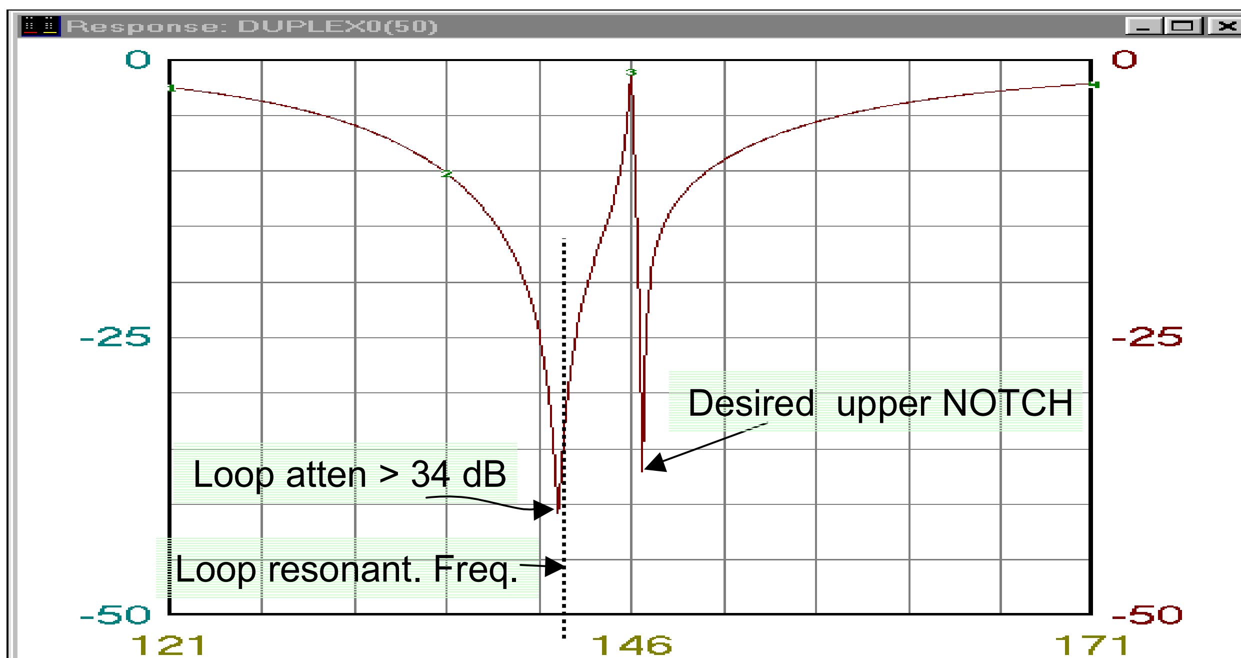
BEST DONE WITH THE LOOP REMOVED FROM THE CAVITY

UPPER NOTCH - ABOVE BANDPASS: (see the graph below)
THE LOOP SHOULD RESONATE FROM ~ 130 to 140 MHz

LOWER NOTCH - BELOW BANDPASS:
THE LOOP SHOULD RESONATE FROM ~ 150 to 160 MHz

SHOULD GIVE AT LEAST 34 dB ATTENUATION (IN A 6 in. CAVITY)

AS SHOWN HERE:
THE LOOP RESONANT
FREQ. AND ATTEN.
MAY ALSO BE
OBTAINED FROM
THE CAVITY
RESPONSE



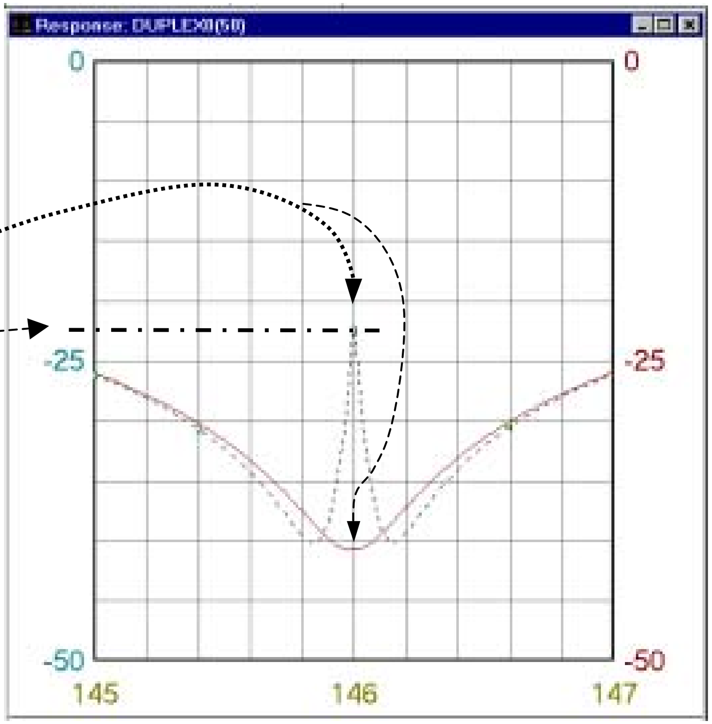
NOTCH - BANDPASS CAVITIES

Qu FACTOR VERIFICATION

ADJUST THE RESONATOR AND THE LOOP TO RESONATE AT THE SAME FREQUENCY

ADJUST THE COUPLING FOR ~ 20 dB ATTENUATION

MEASURE THE -3 dB FREQUENCIES AND CALCULATE Qu AS PREVIOUSLY DESCRIBED

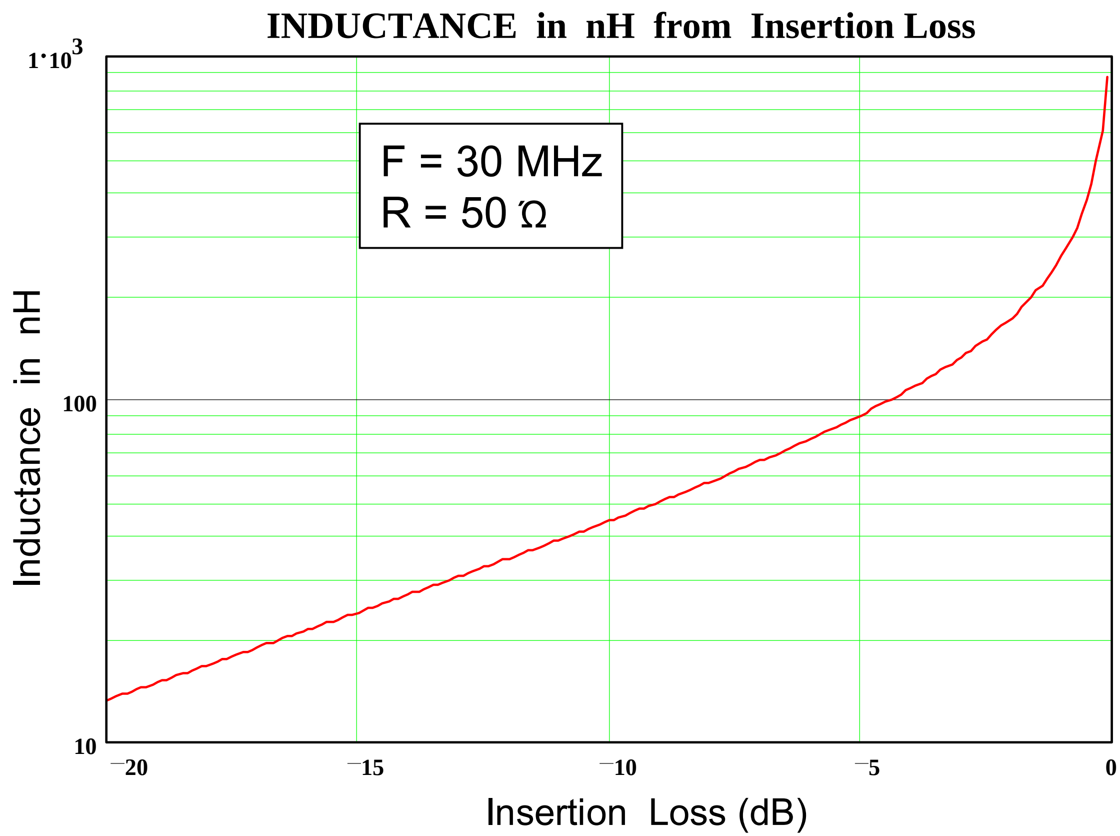


Qu FACTOR VERIFICATION

MEASURING LOOP INDUCTANCE

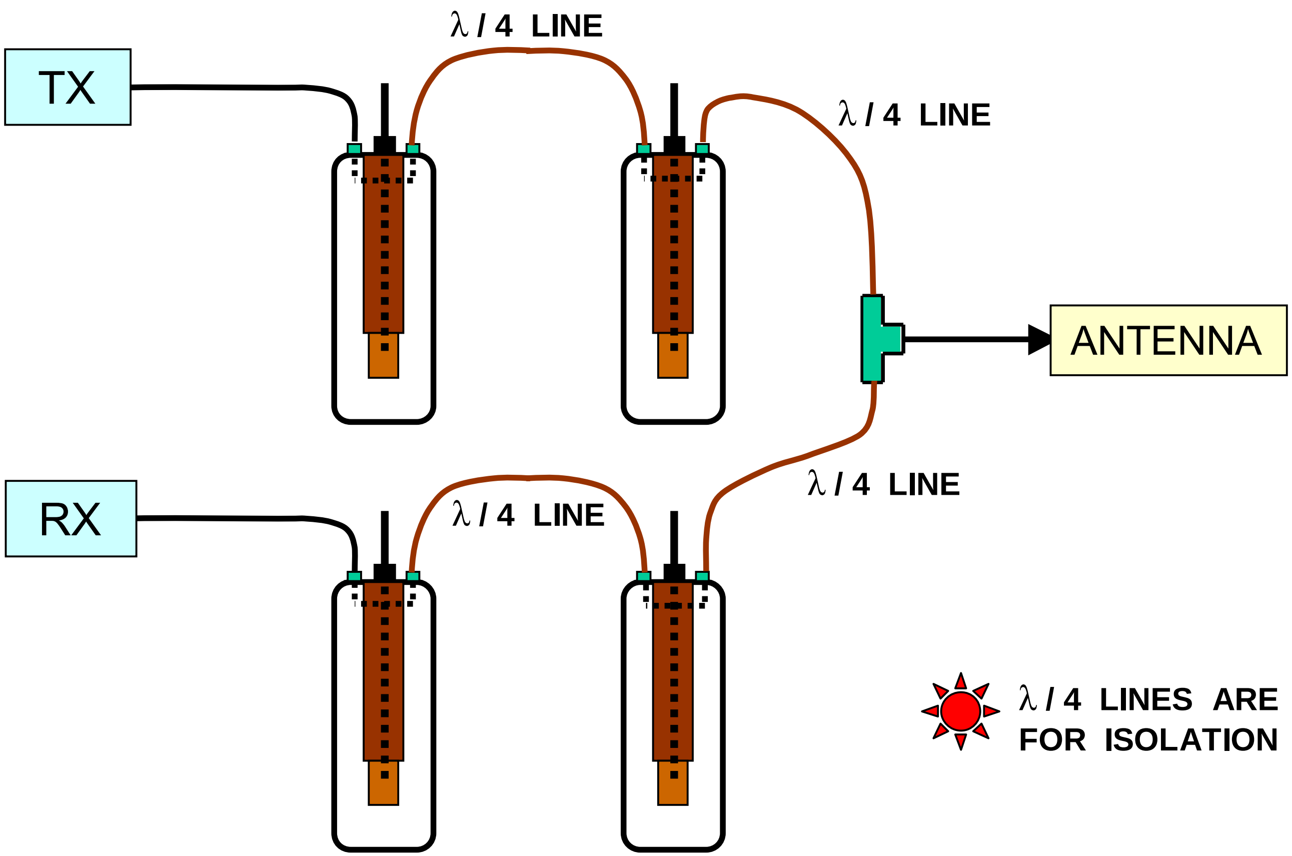
MEASURE THE ATTENUATION IN dB CAUSED BY INSERTING THE LOOP IN A SHUNT CIRCUIT WITH A GENERATOR / DETECTOR IMPEDANCE = R (ohms) AT A FREQUENCY: F in MHz AND COMPUTE THE INDUCTANCE L in nH:

$$L = \frac{79.58 \cdot R \cdot 10^{\frac{dB}{20}}}{F \cdot \sqrt{1 - \left[10^{\left(\frac{dB}{20}\right)} \right]^2}} \quad \text{in nH}$$



PUTTING IT ALL TOGETHER

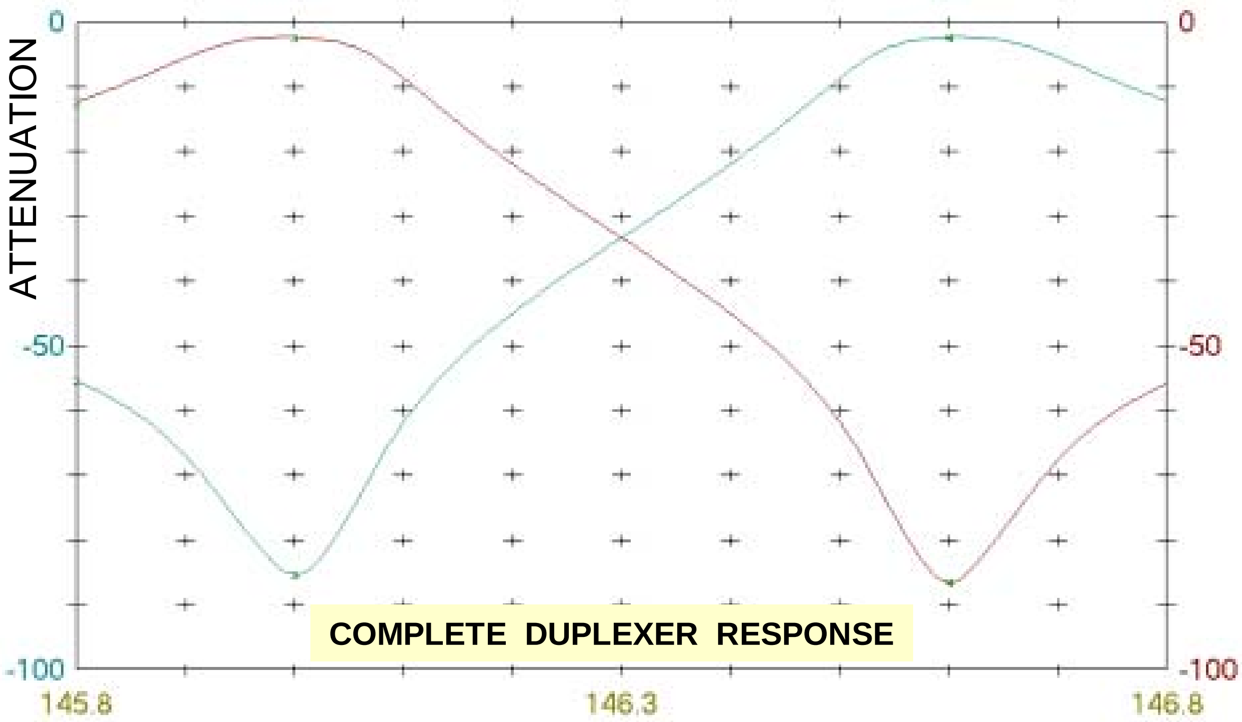
DUPLEXER BUILT WITH FOUR 6 in. SERIAL LOOP CAVITIES



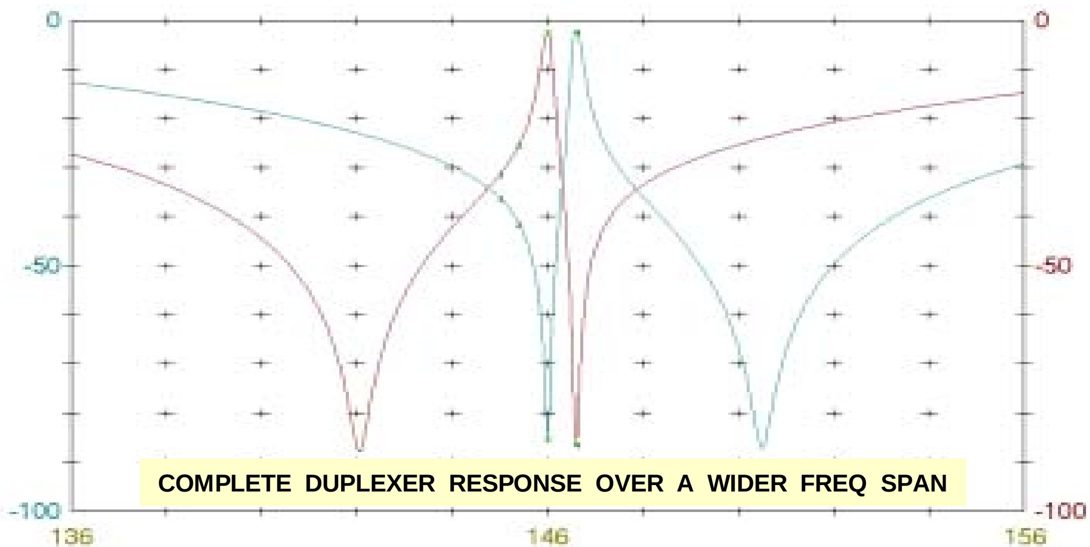
λ / 4 LINES ARE REQ'D FOR ISOLATION

EXAMPLE OF DUPLEXER BUILT WITH FOUR 6 in. SERIAL LOOP CAVITIES

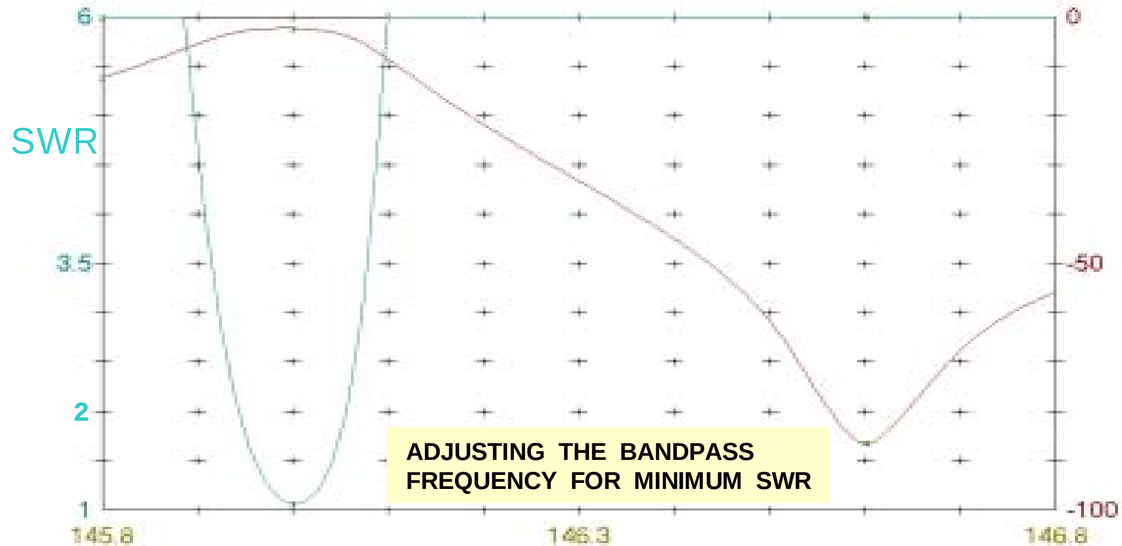
- ❑ BANDPASS INSERTION LOSS: ~ 2.2 Db (1 dB PER CAVITY + λ/4 LINE LOSSES)
- ❑ NOTCH DEPTH: ~ 85 dB
- ❑ NOTCH DEPTH = ~ SUM OF NOTCH DEPTH OF EACH CAVITY + 5.5 dB ***PER*** λ/4 LINE
  Example: NOTCH DEPTH = 37 dB + 37 dB + 5.5 x 2 cables = 85 dB



EXAMPLE OF DUPLEXER BUILT WITH FOUR 6 in. SERIAL LOOP CAVITIES



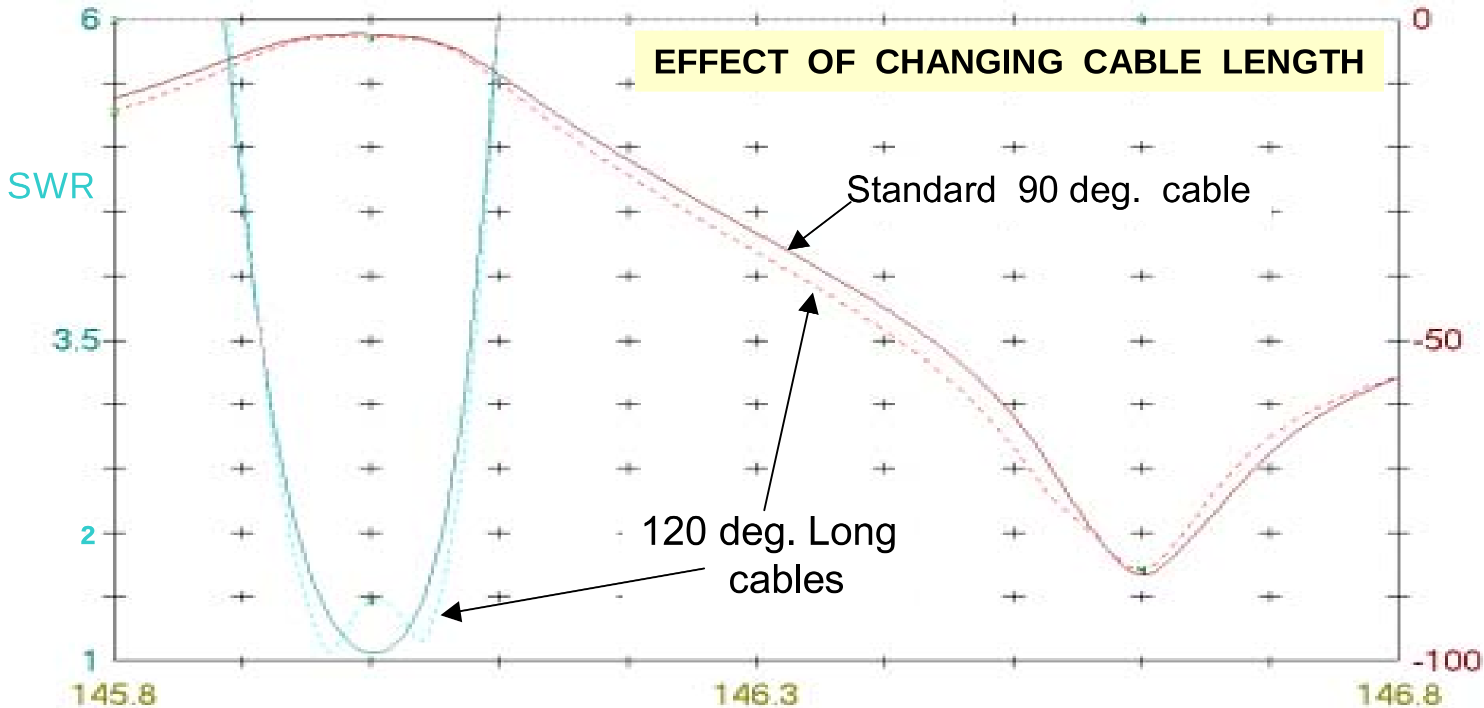
- THIS TYPE OF DUPLEXER PROVIDES LITTLE REJECTION OF OUT OF BAND SIGNALS



- ADJUSTING THE BANDPASS FREQUENCY FOR MINIMUM SWR IS BEST
- MAY REQUIRE ABILITY TO READ LOW SWR VALUES

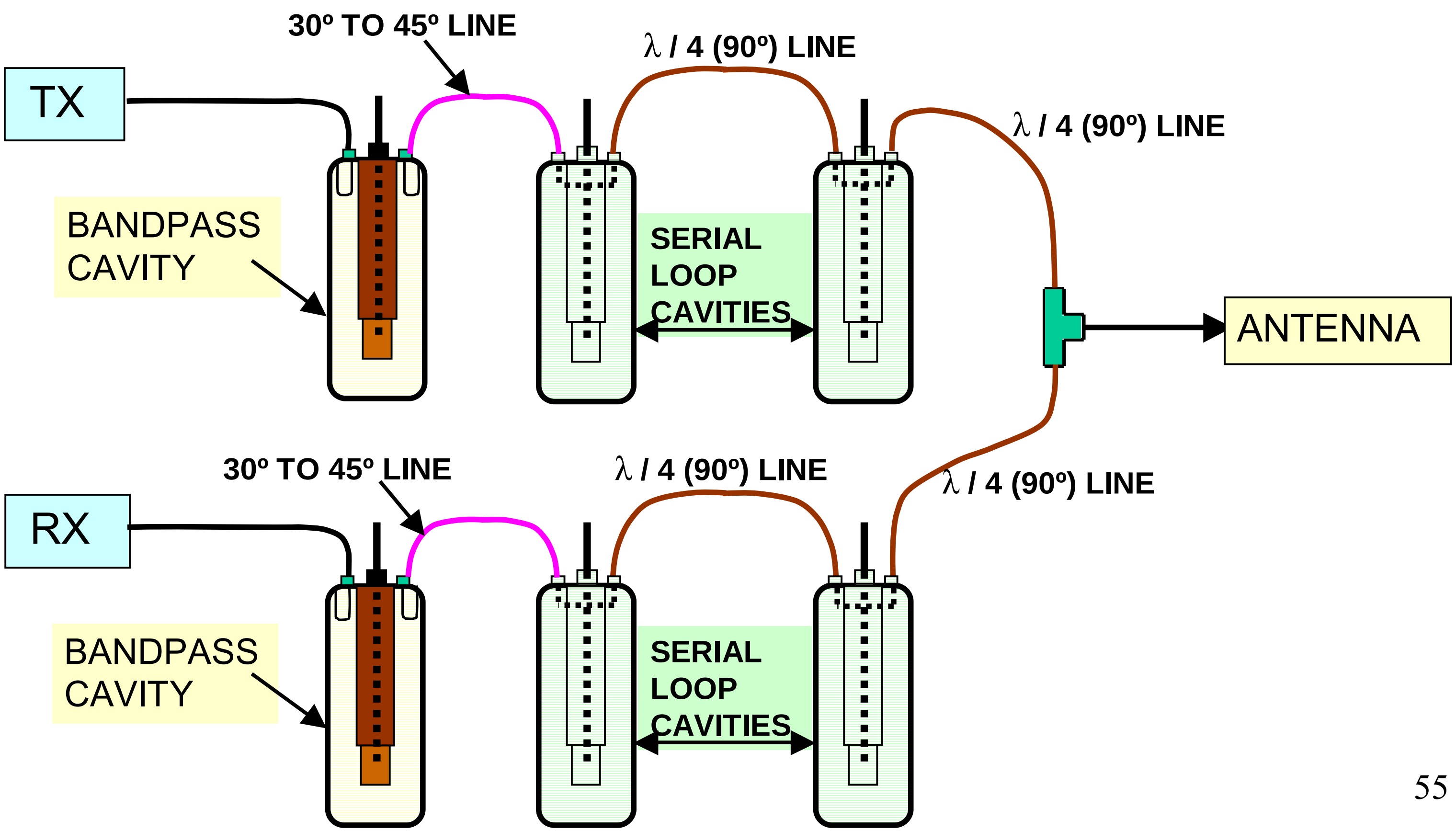
EXAMPLE OF DUPLEXER BUILT WITH FOUR 6 in. SERIAL LOOP CAVITIES

- THE λ/4 CABLES AT THE TEE JUNCTION HAVE BEEN INCREASED IN LENGTH 33%
- SLIGHT CHANGE IN RESPONSE
- SWR CURVE HAS RIPPLES NOW. THIS MAY BE USED TO CHECK FOR PROPER CABLE LENGTHS



EXAMPLE OF DUPLEXER BUILT WITH TWO BANDPASS + FOUR SERIAL LOOP CAVITIES

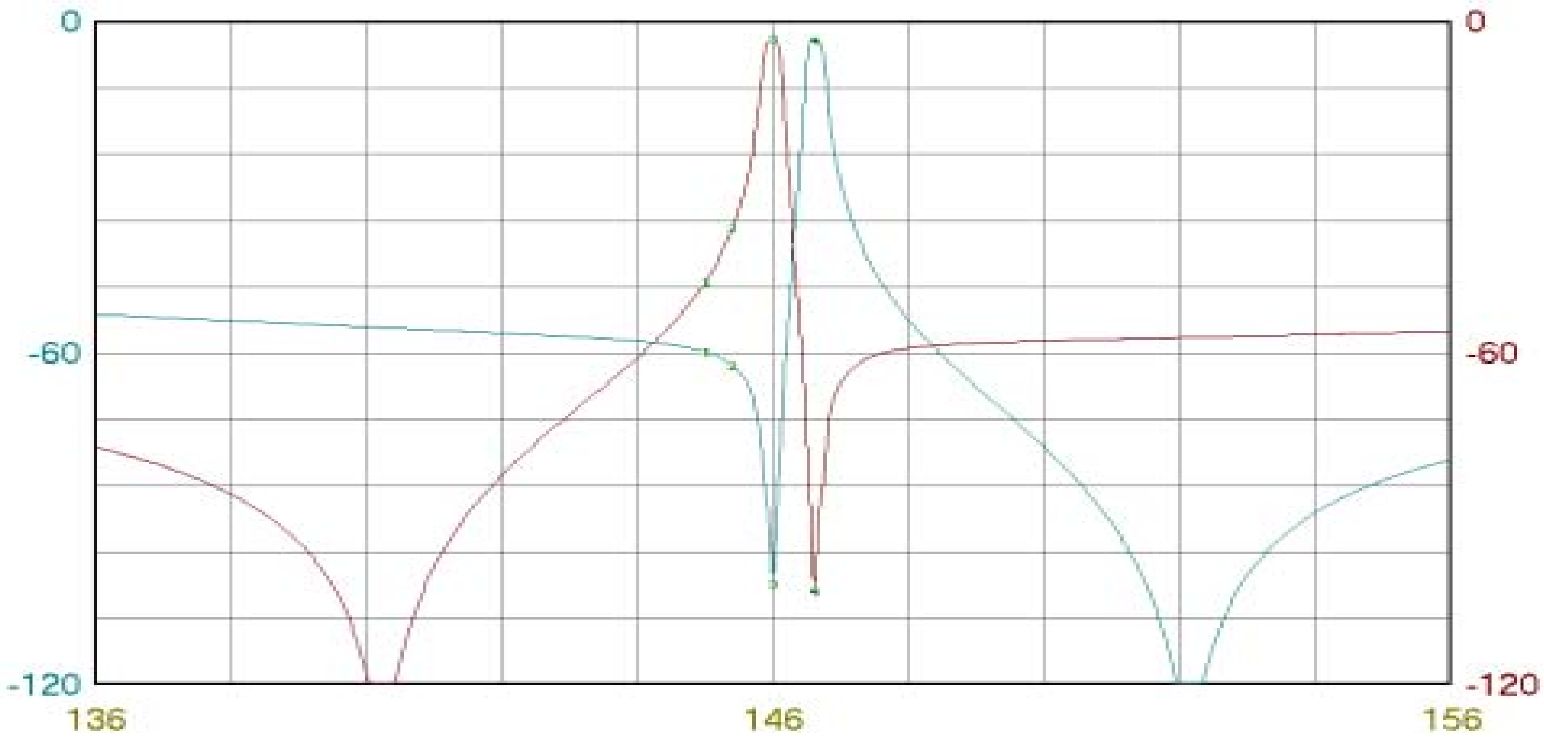
- BANDPASS CAVITIES SHOULD BE PLACED AHEAD OF SERIAL LOOP CAVITIES
- THE 30º TO 45º LINE AFTER THE BANDPASS CAVITIES ADDS ~ 5dB NOTCH DEPTH
- IMPROVES REJECTION



EXAMPLE OF DUPLEXER BUILT WITH TWO BANDPASS + FOUR SERIAL LOOP CAVITIES

FEATURES:

- 3 dB BANDPASS LOSS (~ 1dB per cavity)
- ~102 dB NOTCH
- EXCELLENT REJECTION OF OUT OF BAND SIGNALS



COMPLETE DUPLEXER RESPONSE OVER A 20 MHz FREQ SPAN

PITFALLS

- AVOID LOW QUALITY CONNECTORS SPECIALLY TEES.

  The picture on the right shows an N type connector that uses a steel spring for making contact with the thru line. The added inductance was calculated from return loss measurement at 100 MHz (9.5 dB) and 1 GHz (5 dB) with both female ends terminated (50 ohms) This gave ~ 7 nH inductance. Therefore a 100 nH loop will have its inductance increased by 7%, thus lowering its resonant frequency 3.5% or ~ 5 MHz at 146 MHz **!**

- USE SILVER PLATED CONNECTORS

- UNPLATED COPPER CAVITIES MAY BE POLISHED AND CLEANED WITH "BRASSO" (liquid copper / brass cleaner) LEAVES A PROTECTIVE FILM

- SLIDING CONTACTS MAY BE LUBRICATED WITH SILICONE CLEANER OR VASELINE

- TERMINATE THE "UNUSED" PORT WHEN TESTING FOR LOSS OR SWR

N Type Tee

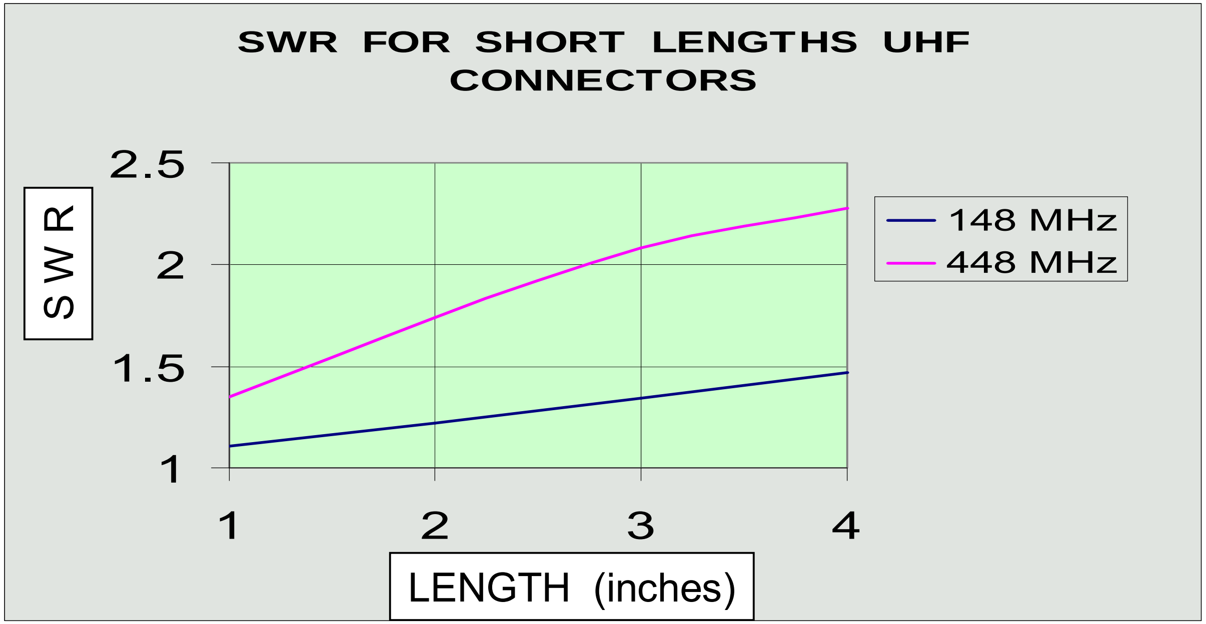
CENTER CONNECTOR USES A SPRING FOR CONTACT !

PITFALLS

- TEMPERATURE SENSITIVITY:
  UNCOMPENSATED Cu RESONATORS WILL SHOW
  A TEMPERATURE COEFFICIENT OF ~ -1.3 KHz / degC (146 MHz)

- DOUBLE SHIELD CABLES AND N TYPE CONNECTORS PREFERED

- AVOID – IF POSSIBLE - UHF ADAPTERS
  THEIR IMPEDANCE IS BELOW 50 OHMS: ~33 OHMS
  THEY WILL LIKELY INCREASE THE SWR



CONCLUSION

- THIS PRESENTATION COVERS THE MOST IMPORTANT DUPLEXER ELEMENTS:
  BANDPASS + 3 TYPES OF NOTCH – BANDPASS + NOTCH DESIGNS

- SIMULATION SOFTWARE WITH REAL TIME TUNING CAPABILITIES ALLOWS « BREADBOARDING » DUPLEXERS

- LEARN TUNING, CHECK FOR SENSITIVITY TO COMPONENT VARIATIONS SUCH AS Q FACTOR, CABLE LENGTHS ETC.

REFERENCES

- LINEAR SIMULATION SOFTWARE:
  SuperStar from Eagleware (used here)
  Serenade SV for Windows from Ansoft (free)
  ARRL Radio designer from ARRL
  Pspice Student version
- Duplexer Theory and Testing by Dave Metz WA0UAQ (.pdf format)
- KI7DX 6 Meter Repeater http://www.wa7x.com/ki7dx_rpt.html
- 6 Meter Heliax Duplexers http://www.dallas.net/~jvpoll/dup6m/dup6m.html
- Duplexers: theory and tune up http://www.seits.org/duplexer/duplexer.htm
- Upgrading Boonton Models 92/42 RF Voltmeters Jacques Audet
  Communications Quarterly Spring 97

- THANKS to Jean-Nicol VE2BPD for the photos and the bad tee