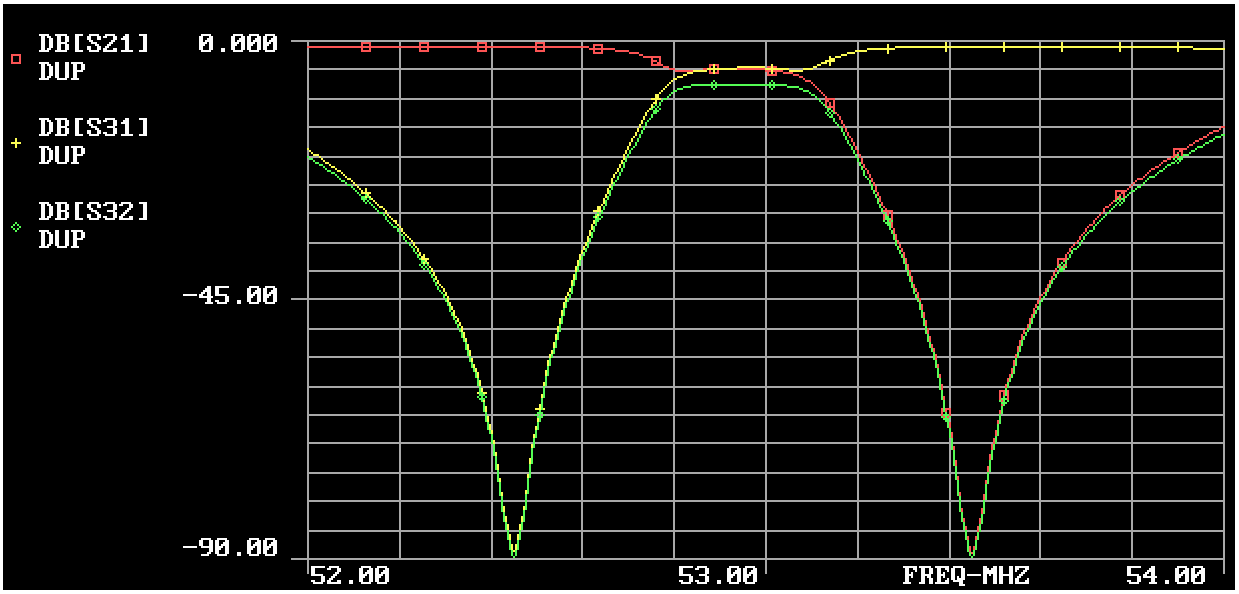
Six Meter Heliax Duplexers



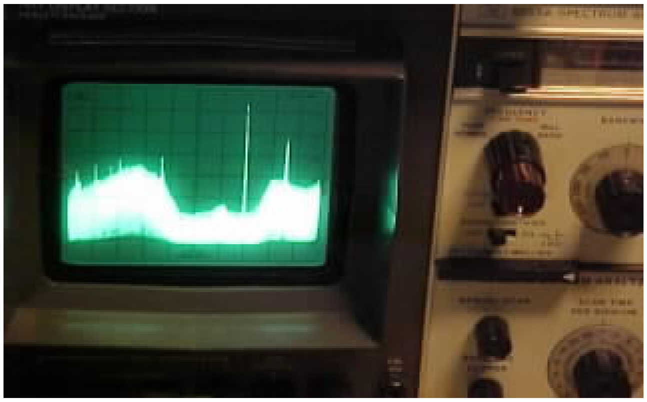
Low-band VHF Heliax Duplexer Performance on 6 Meters, Notch Style

Shown above is a graphic displaying the performance of a ***3rd generation,*** 1 MHz split, 90 dB Isolation, 1 dB Insertion Loss, 6 stub Six Meter Heliax Duplexer *using notch technology* operating on a 52 MHz in / 53 MHz out frequency pair. This graphic shows the following "S21" S-Parameter sweeps:

1. S21 measurement, measured from the receive port to the antenna port (square/red line --------),
2. S31 measurement, measured from the transmit port to the antenna port (plus sign/yellow line --------) and
3. S32 measurement, the 'isolation' a duplexer exhibits from receiver to transmitter measured from the receive port to the transmit port (diamond/green line ---------).

The Insertion Loss in the 'passband' of this duplexer measured 1 dB; this is excellent performance for a duplexer this size, this weight and form factor, especially when compared against some of the *cabinet-hoggers* and six-foot can designs that are doing service on VHF Low-band. S11 on each port is equally impressive; over 20 dB RL on each port (see further below for S11 sweeps).

Shown on the HP 8405A Vector Voltmeter (to the left) is a value indicating ***well over 85 dB of attenuation*** (or 'notch depth') on the left meter for a recently-built duplexer constructed out of 1 5/8" Heliax. This duplexer, a compact, closed-top design exhibited



around 1 dB IL for the Xmit and Receive legs each at their respective 'pass' frequencies. (In the picture the HP 8640B generator is set for 0 dBm output, the HP 8405A is set to the -70 dB range and the meter is indicating *well to the left* of the -10 dB scale marking.) *Experience has shown* that with proper design (including simulation/modeling with such tools as Agilent/EESOF's Touchstone) and construction *a stub duplexer can be built which yields* ***90 dB of isolation*** with attendant Insertion Loss values (for the receive and transmit 'pass bands') right around 1 deciBel.

Shown to the left (on the CRT of an HP 8555A/141T Spectrum Analyzer) is typically what is seen at the *receive port* of a stub duplexer and what is often presented to a receiver connected there.

Note that the center frequency on the spectrum analyzer corresponds to the receive frequency and with the dispersion is set for 500 KHz/div the transmit carrier (from an Azden PCS-7500H, nominally a 50 Watt radio) can be seen two divisions 'up the band' (1 MHz away) at -46 dBm.

The noise floor of the spectrum analyzer in that photo is approximately -100 dBm. Note that several spurious outputs from the Azden PCS-7500H can be seen both above and below the two 'notch' frequencies where the receive and transmit stubs work their 'magic'. The Azden PCS-7500H would not be the ideal choice for use as a repeater transmitter; sooner or later the choice of a particular frequency could result in a 'spurious signal' on the repeater's receive frequency ...

-- History --

The history of this duplexer design for Six Meters dates back to the late eighties when I began *several years of low-level research* involving the mathematical analysis, simulation and 'bench work' on shorted Heliax stubs; work that finally culminated in a ***proof-of-concept prototype design*** in about '**91** which was constructed out of 1 1/4" Heliax. Since 1991, much additional work has been done with 1 5/8" Heliax with better results.

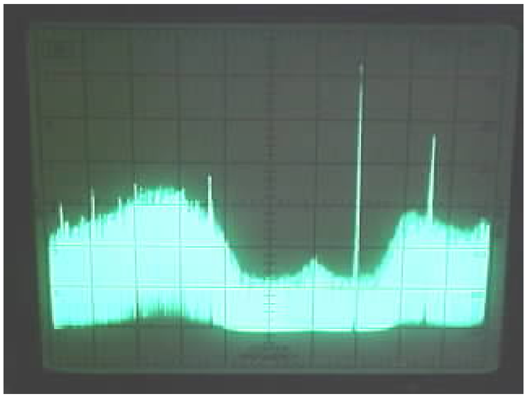
-- *3rd Generation design,* a rugged, compact physical configuration --

Compact, closed-top design, UPS-shippable, under going testing in lab

To the left: Another view of the **compact, closed-top duplexer design** built using 1 5/8" Heliax custom cut and built for use on a customer's 6M repeater frequency pair.

In this compact, closed-top, ***3rd generation design*** (others have claimed a '2nd generation' design utilizing a box built of copper-clad PC-board material sitting atop the Heliax stub) the interconnecting coaxial cables between stubs and input/output coaxial cables are ***soldered in place*** - this works to solve a *couple of problems* that can occur in time, over the life of equipment:

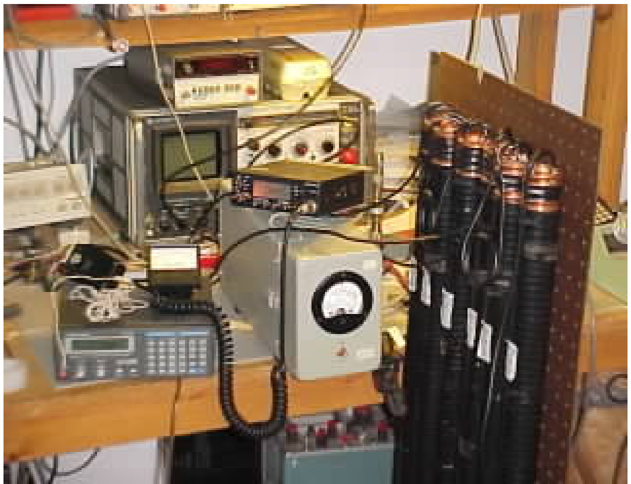
- a) Fewer connectors to clean, or keep clean, over the life of the duplexer. There are only <u>four</u> (4) BNC connectors (excluding the BNC tee used at the common antenna junction) in this design. Compare that with a total of ***12 connector pairs*** (24 individual connectors; 12 male and 12 female) dedicated to stub connections alone on a conventional 'fully-connectored' design, *plus* the 2 connectors present on the cables at the BNC Tee junction ... compare that again to only -4- connectors present on the compact, closed-top design that is described here.
- b) ZERO chance of someone 'borrowing' *one of your nice BNC-connectored interconnecting cables* for some other purpose (not everyone enjoys exclusive access to their own repeater 'hut' at the base of a tower or on a mountain top!)



In the last 6 or 7 years many other people have successfully built notch-reject Heliax duplexers making *minor physical changes* (resulting in what they describe as 'a 2nd generation' design) from the prototype I first detailed on this web page; the theory and modeling remains the same *regardless* of these changes *although* 'bench work' has shown that *certain physical configurations* are less desirable than others (those with LARGE, dressy enclosures or boxes on top of their stubs - take note!). In my testing this has usually shown up in area of the notch's pass-band response (**it's EASY** to get *notch depth*; **it's HARD** to obtain the *optimum minimum insertion loss* at the 'pass' frequency). I can easily measure *insertion loss changes* of **0.1 dB** using lab instrumentation such as the HP 432A RF power meter; with or 3 or 4 stubs in a duplexer *these losses add up*.

-- Duplexer Types --

In the world of duplexers, there basically four different types:
a) BP - Band Pass, built using tuned/resonant elements which 'pass' one particular frequency
b) BR - Band Reject, built using tuned/resonant elements that 'notch' out one particular frequency
c) BPBR - Band Pass Band Reject, a combination of the above
d) HPLP - High Pass Low Pass, built using high pass fitlers and low pass filters.
The duplexer described on this web page **is a *Band Reject*** (BR) type **duplexer** as opposed to a (sometimes more desirable, depending on the application) ***Band Pass*** (BP) **duplexer**. *This means that* deep attenuation 'notches' are provided for 1) receiver protection (from the transmitter's output) *as well as* 2) transmitter noise (at the receive frequency) as can be seen in the photo below where the two 'notches' appear in the 'noise'.



In the picture to the left, the transmit power from the Azden PCS-7500H into the transmit port of the duplexer was approximately 55 Watts.

The resulting *transmitter carrier level* on the receiver port of the duplexer, and measured the Spectrum Analyzer, was -46 dBm; suitable for most commercial grade receivers and almost usable with a Radio Shack PRO-2006. (The PRO-2006 is equipped with a wide-band, untuned front end.) In fact, a PRO-2006 was tested with a stub duplexer exhibiting over 90 dB of attenuation and it experienced *no* desense (aside from the transients seen during transmitter 'key-up') when the Azden was set to transmit low power (12.5 watts) into the xmit port of the duplexer.

When the Azden (pictured at left with the Radio Shack PRO-2006 during a duplexer noise test) was used at high power (55 W) approximately 3 dB of desense was experienced by the PRO-2006.

As was mentioned previously, with the Azden set for the 12 Watt (low) power level <u>no</u> desense/noise (exc during key-up when it is assumed the synthesizer is 'locking') is heard, seen or otherwise experienced.

Anyway, getting back to the discussion of BR versus BP duplexer designs, the attenuation of 'out of band' signals *is less* with a BR design than that achievable with a BP design (although there is *some* attenuation of 'out of band' signals with a BR design). Normally, at low-band VHF frequencies (30 - 54 MHz) this is not a problem; receivers used for repeaters should be those equipped with helical resonator front ends and not the wide-band lumped LC found in the cheaper mass-produced 'consumer' or the low-end 2-way market.

The benefits of BR duplexer designs are:

1. *reduced insertion loss* - lower IL values can be obtained than those of a BP design *given* the same 'Q' and number of resonators using either 'cavities' or stubs and
2. **BR duplexers are more suitable for close spacing 'splits'** (repeater splits) when working with a small number of Q-limited (non-optimum Q value) resonant elements such as 1 1/4" or 1 5/8" Heliax Stubs.

1 5/8" Heliax stubs are *no substitute for* 3" or 5" diameter cavities in narrow-spaced repeater operation (as on **2 Meters**) *if* low insertion loss is desired. As it turns out though, with proper design Heliax stubs *are* suitable for use as 'stubs' (sometimes loosely called 'cavities') in a ***BR duplexer*** **design on the 6 Meter band.**

A *Band Pass* (BP) duplexer *can* be implemented using Heliax stubs (the same type of stubs as described on this page, stubs that nominally exhibit a deep 'notch' at one frequency) in a *Hybrid Ring Duplexer* configuration. Simulations show slightly higher *insertion losses* at each of the two 'pass frequencies' in a Hybrid Ring Duplexer using stubs whose Q is in the range of that obtainable from 1 5/8" Heliax. See the page on details regarding a *Hybrid Ring duplexers* on this page.

-- Duplexer Requirements --

A duplexer must provide one basic thing: *Adequate isolation* between a receiver and transmitter to allow simultaneous operation of both, often described as 'duplex' or 'full duplex' operation. A duplexer accomplishes this by providing 'isolation' at basically two frequencies: the receive frequency and the transmit frequency. This isolation or *filtering* must address two main 'energy' components output by the transmitter, as well as couple both the receiver and the transmitter to the antenna with minimum practical insertion loss.

The two main 'energy' components output by the transmitter are:

a) the transmit carrier (at the transmit frequency) at a power level of between 25 and 100 Watts, and
b) transmitter *noise* that appears at the *receive* frequency.
The duplexer must reduce both of these 'energy' components to levels that:
a) do not 'block' or 'overpower' the receiver (like the transmit carrier can do without a duplexer) and
b) do not obscure, 'cover' or mask weak, microvolt-level signals intended to be picked up by the receiver.

60 Watt Transmitter Noise and Carrier budget

Perusing some Motorola and General Electric 2-way radio service manuals I find that most commercial radios specify the "spurious and harmonic" energy levels as being "85 dB below the (transmit) carrier". That means that any energy, other than the carrier itself, will be at least 85 dB weaker than the transmit carrier.

The following chart shows the signal environment a 60 Watt transmitter and it's corresponding noise spec can create using three different duplexer Isolation values (80, 85 and 90 dB). Additionally, the performance figures for the 60 Watt transmitter are shown for transmitter 'spurious and harmonic' noise specifications of 80 dB and 85 dB just to give us some room to see what 5 dB worse performance gives us.

	Dup Attn	Xmt noise	Atn Noise	Xmtr Level	Rcvr Noise
Power W	dB	dB down	uV rms	dBm	dBm
60	80	80	0.55	-32	-112
60	85	80	0.31	-37	-117
60	90	80	0.17	-42	-122
60	80	85	0.31	-32	-117
60	85	85	0.17	-37	-122
60	90	85	0.10	-42	-127

The chart above (and below) uses the following abbreviations:

Dup Attn, dB	- Duplexer attenuation or Isolation value. Isolation values of 80, 85 and 90 dB are shown in this chart.
Xmt noise, dB down	- Transmit noise, in dB down per transmitter specification, two groups here, 80 and 85 dB.
Atn Noise, uV rms	- Attenuated Noise in microvolts rms on receiver frequency.
Xmtr Level, dBm	- Transmitter signal level, in dBm, as seen at receiver port of the duplexer.
Rcvr Noise, dBm	- Receiver Noise level in dBm (rather than microvolts as the Atn Noise column shows).

For instance, for a 60 W transmitter with an 85 dB 'spurious and harmonic' specification, a duplexer with an 85 dB 'Isolation' value should show only .17 uV rms of transmitter noise at the receive port and the transmit carrier level will be at -37 dBm.

100 Watt Transmitter Noise and Carrier budget

Power W	Dup Attn dB	Xmt noise dB down	Atn Noise uV rms	Xmtr Level dBm	Rcvr Noise dBm
100	80	80	0.71	-30	-110
100	85	80	0.40	-35	-115
100	90	80	0.22	-40	-120
100	80	85	0.40	-30	-115
100	85	85	0.22	-35	-120
100	90	85	0.13	-40	-125

For a 100 W transmitter with an 85 dB 'spurious and harmonic' specification, a duplexer with a 90 dB Isolation value should show only .13 uV rms of transmitter noise at the receive port and the transmit carrier level at the receive port will be -40 dBm.

-- Duplexer Specs --

Duplexer performance can be measured and quantified with three main figures:
1) Insertion Loss,
2) Isolation (TX and RX Isolation) and
3) Return Loss.
I prefer using the term *return loss* to SWR or VSWR since so very few of us actually measure 'VSWR' directly; usually, we measure *return loss* using a directional coupler (or a directional Watt meter like the famous Bird series) and convert this figure to VSWR

using the usual, well-established formulas and via HP's APPCAD utility or the venerable HP VSWR "Reflectometer" slide rule.

To that end, the following close relationships exist between Return Loss and VSWR:

Return Loss	VSWR
14 dB	1.5:1
18 dB	1.3:1
21 dB	1.2:1
26 dB	1.1:1

Insertion Loss

This value is the *measured loss* in the *pass band* of the receiver (or transmitter) leg between the receiver (or transmitter) port and the antenna port at the respective receive (or transmit) frequency. This value represents the small amount of *attenuation* or 'insertion loss' that results when the duplexer is placed in-line between the receiver or transmitter.

The following chart shows the reduction in *transmit power* due to the *Insertion Loss* of the duplexer. A 1 MHz split, 90 dB notch duplexer, properly designed and built, paying particular attention to the key physical parameters that determine the recovery from the 'deep' attenuation notch are capable of achieving insertion loss values of around 1 dB. In the 3rd generation design this is accomplished using microstrip techniques.

dB Insertion Loss and power out for 100W transmitter	dB	W	dB	W	dB	W	dB	W
	0.7	85	1.1	78	1.5	71	1.9	65
	0.8	83	1.2	76	1.6	69	2.0	63
	0.9	81	1.3	74	1.7	68	2.1	62
	1.0	79	1.4	72	1.8	66	2.2	60

Isolation

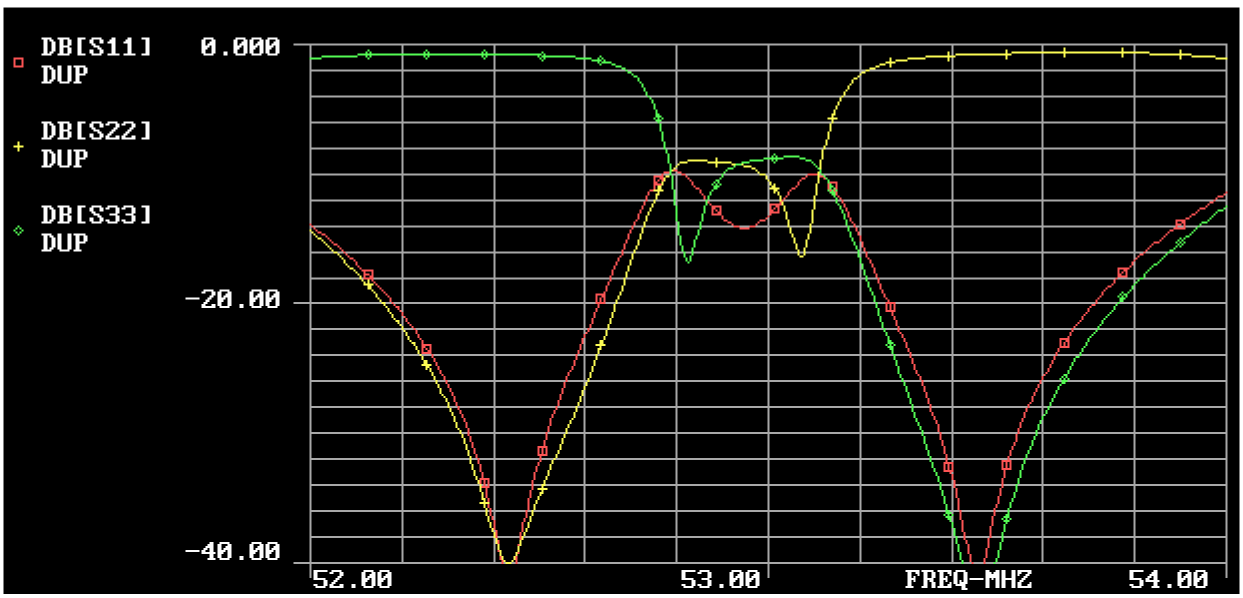
This value is the measured *isolation* between the Transmit port (port 3) and the Receive port (port 2). In S Parameter parlance on this web page, this is the *S23* value.

The 'Isolation' figure reveals the amount of isolation between the transmitter and the receiver. Two such 'values' for isolation exist for every duplexer, one for the receive frequency and one for the transmit frequency.

Freq	S21	S31	S23
52.450	.988 dB	88.6 dB	89.5 dB
53.450	88.8 dB	.968 dB	89.7 dB

Return Loss (VSWR)

The *return loss* value, directly related to the VSWR (Voltage Standing Wave Ratio), is a measure of the *match* the duplexer presents to the transmitter, the receiver, and even the antenna. Below is the sweep obtained during modeling of a Heliax duplexer design. Practical experience shows that comparable results can be achieved when building the Heliax duplexer - I regularly obtain Return Loss values better than 25 dB translating to a VSWR of around 1.1:1.



Commercial product - comparison

For comparative purposes, via www.repeater-builder.com/rbtip/duplexerspecs.html we can see what the key performance parameters are for a commercial DB-4032 (an 8-can helical resonator VHF low-band duplexer):

```
---------------------------------------
Type: 8 helical resonators, bandreject
Minimum freq. spacing      0.5 MHz
Insertion loss             2.0 dB
Max. continuous power      150 watts
Tx noise supp. at Rx freq. 80 dB
Rx isolation at Tx freq.   80 dB
VSWR                       1.5:1
---------------------------------------
```

1.0 General Description

This web page describes both an ***early prototype Six Meter Duplexer*** and subsequent improvements in design by WB5WPA that nominally consist physically of:

- **Six (or eight)** band-reject coaxial "stubs" fabricated from 1 5/8" Heliax stubs (read that as: "*one and five-eighths inch Heliax stubs"*). Note that 1 1/4" ("*one and one-quarter inch")* Heliax stubs were used in developing the *original prototype* (which is still in service) and results in slightly poorer RF performance than the larger diameter 1 5/8" Heliax.
- **Six (or eight)** 'gimmick' caps fabricated from (approx.) 3" lengths of RG/8, inserted in the Heliax stubs and forming a series-resonant 'tuning' capacitor. The final length is determined during the 'tuning' process.These 'gimmick' caps are a cost effective way of achieving high-Q, high operating RF-voltage caps without the expense of commercially purchased parts.
- **Six (or eight)** inter-connecting coax jumpers made of 1/4 Lamda (electrical) lengths of RG/58 cable. It isn't absolutely necessary to use double-shielded RG58 cable at 6M frequencies for attenuation values of 80 dB or so.
- **Three (or four)** (each) Shunt inductors/capacitors. These serve to recover from the deep notch attenuation at the reject frequency as one approaches the 'pass' frequency.

The first ***proof-of-concept*** (engineering) unit that was designed and built has proven itself over the last ~~five~~ (oops - it's ~~1997 1998 1999 2000 2001 2002 2003~~ 2004 make that ~~six seveneight nine ten eleven~~ **thirteen** years.

This original *prototype* duplexer built used 1 1/4" Heliax (that's all I could find at the time) and possessed the following key specifications:

- Fabricated from **1 1/4" Heliax** (One and one quarter inch foam dielectric Andrews-brand Heliax)
- **1/2 MHz Repeater 'split'** (500 KHz repeater offset)
- **Notch depth** (attenuation), each leg**: 73** dB
- **Insertion loss** (each leg): Approx. **1.5** dB

Larger Heliax (such as 1 5/8") is recommended for a 1/2 MHz split because of the lower insertion losses that will be seen. Using 1 5/8" Heliax at the proper length also achieves a little more *notch* (attenuation) depth - with a corresponding lower IL (insertion loss) resulting in better than the 1.5 dB achieved by my first 1 1/4" Heliax design.

Changes in notch frequency due to temperature changes is negligible. I 'soaked' several stubs in cold (winter) and hot (summer) temps and could see no real appreciable change - this surprised me. I had to wait till the passage of those seasons since I don't own -and didn't at the time have access to- an environmental chamber large enough to test 1/4 lambda stubs. I'm a big believer in "testing over temperature".

Section 1.1 Duplexer Stub-Length Calculation.

If you're running Netscape 2.0x or greater, click here on Calculate rough length to run a short Javascript that will calculate the rough physical length of a stub constructed of Andrews LDF (Low Density Foam - not Air dielectric line) Heliax.

Note: The actual length determines a variety of physical parameters in a duplexer design including notch depth, Insertion Loss (in the receive and transmit pass bands) and affects other component values such as the shunt inductor and shunt capacitors that are used to 'recover' from the attenuation that the notches provide.

2.0 1 5/8" Heliax Six Meter Stub Duplexers: Attenuation and Insertion Losses

Designs have been tested for 0.5 MHz and 1.0 MHz spacing (or 'split') repeater systems and the general performance specs for these two "splits" are shown below. For construction details (even though they are kind of specific to just my first design) read Section 3.0 titled "My First Six Meter Duplexer".

Now, a word about 'repeater splits'.

I favor the **1/2 MHz repeater split** on six meters because of the limited working bandwidth of practical antennas at these frequencies, especially the professionally built antennas like the DB Products folded ground plane and folded dipoles, antennas that will last and stand up to the effects of weather over time and don't generate broadband 'white noise' when excited with RF in a full duplex operation like some cut-down CB ground planes have been found to do. Others ignore the importance of the antenna and it's construction - usually at their own peril. They may experience 'white noise' desense while the repeater transmitter is on the air, 'crackling' desense as the antenna ages and gets wet and 'popping' noises in the case of some non-DC grounded antenna designs.

At six meters (50 MHz) a two-percent bandwidth specification on an antenna means the antenna has a *usable bandwidth* of 1 MHz where the match ('VSWR', RL, S11, etc.) looks BEST in the *middle* of this 1 MHz range and slowly rises and passes through some value of VSWR (say, 1.7:1) at the edges of that bandwidth. *Any* duplexer will do 'best' into a flat, matched antenna (or load), so, to "keep your 50 Ohm system all 50 Ohms" -or at least nearly so- a matched antenna is really a requirement when working with a duplexer. (Long lost, I think, is the concept that any tuned circuit -including antennas- possess some finite figure of 'Q' that dictates it's inherent bandwidth thereby establishing it's workable frequency range. Remember, *there is no cheating nature at her own game*.)

2.1 ---- RG-58 Electrical 1/4 wavelength Calculation ----

For Netscape 2.0x or greater users Calculate the length of the RG-58 inter-connecting cable. This figure is the physical length of the RG-58 interconnecting (between notches, and the Tee junction) cables.

2.2 ----- Typical 1 5/8" Heliax Duplexer Performance ------

In the cases below, approximately 36" physical lengths of RG-58 are used between stubs and to the BNC "tee" junction where the antenna is connected. Marginally better performance can be had by calculating the exact quarter wavelength for the frequency for which the notchs have been designed.

2.2.1 Typical Performance, 1 5/8" Heliax stubs, -- 1/2 MHz split Duplexer--, 3 stubs/leg

- Rcv Leg stub length: 44.4"
- Notch attenuation: 80 dB (at xmit freq)
- Insertion loss: 1.7 dB
- Xmt Leg stub length: 44.7"
- Notch attenuation: 86 dB (at rcv freq)
- Insertion loss: 2 dB

Analysis: View the EESOF Touchstone Circuit file used to perform the simulation on this duplexer.

2.2.2 Typical Performance, 1 5/8" Heliax stubs, -- 1 MHZ Split Duplexer--, 3 stubs/leg

- Rcv Leg stub length: 44.1"
- Notch attenuation: 84 dB (at xmit freq)
- Insertion loss: 0.9 dB
- Xmt Leg stub length: 44.9"
- Notch attenuation: 83 dB (at rcv freq)
- Insertion loss: .85 dB

Analysis: View the EESOF Touchstone Circuit file used to perform the simulation on this duplexer.

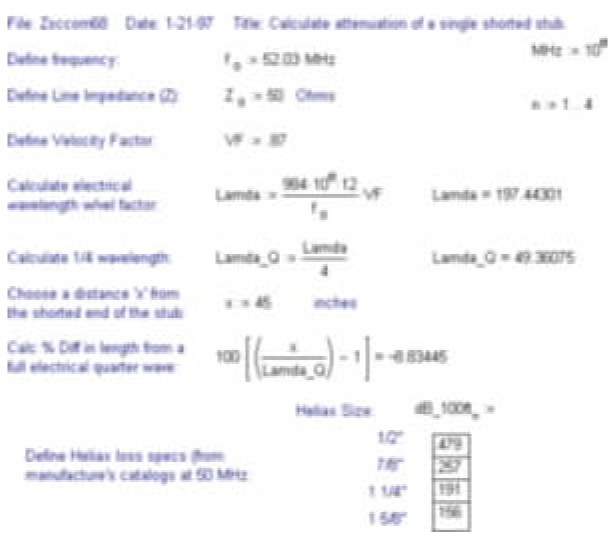
3.0 History of my first *proof-of-concept* 6 Meter Duplexer

The duplexer described here was the result of research/experimentation to see what could be done with available materials (1 1/4" Heliax) and using simple hand tools for what seemed a worst case scenario: a 500 KHz ("half MHz") split (repeater offset) 'machine'. In the process I tested various stub lengths, made measurements and took those measurements back into Mathcad and then finally into EESOF's Touchstone to see what was ultimately possible.

The results have been measured and verified with a variety of test equipment including an IFR 1500, Tektronix 7L12/7613 combo, HP 432, HP 606A an HP Vector Voltmeter.

3.0.1 MathCad Analysis - Heliax Stubs

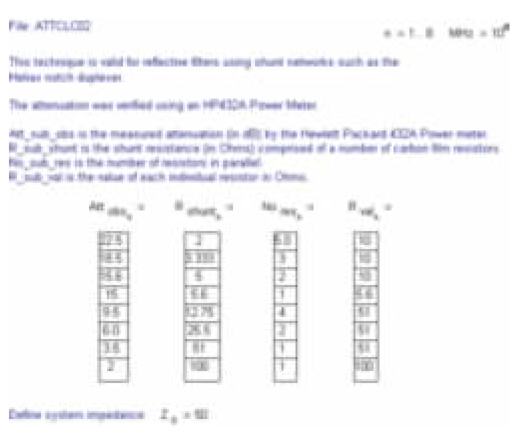
Accessible via the links below are screen captures of *Heliax line analysis* done in MathCad. If you can follow the math I calculate some acceptable IL (Insertion Loss) and notch depth values for 1/2" Heliax up through 1 5/8" Heliax:



Screen 1
Screen 2
Screen 3
Screen 4
All screens together

3.0.2 MathCad Analysis - 'Shunt' Attenuation

An experiment was performed to validate the attenuation that may be seen using shunt elements (*across* rather than *in series with* a 50 Ohm line) and confirm the validity of the attenuation equations used in the analysis of the Heliax stub. Here are the results shown in 'MathCad' screen capture form:



Screen 1
Screen 2
All screens together

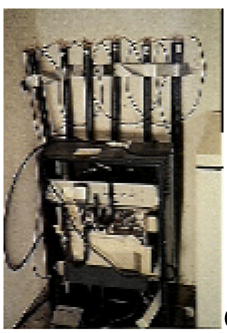
3.1 Building a duplexer

If you wish to Build one (text doc) here is how I described it back then.

3.2 Tuning it up

If you wish to Tune it up (text doc) here are a couple of techniques that can be used to tune it.

3.3 Machines in Service w/Heliax duplexer


GE MASTR PRO Six-meter 1/2 MHz xmit/rcv offset repeater

Click here for Big View of MASTR PRO repeater that has been in service on 52.21 (in) 52.71 (out) north of Dallas, Tx since 1991 using the first duplexer I built. We have also built machines using all Solid State radios such as Motorola Micors on a 0.5 MHz split and a GE MASTR EXEC II on a 1 meg split with no desense using the Heliax duplexer design.

Dan, N5MRG, has had several 0.5 and 1.0 MHz machines on the air - all with good results.

3.4 Reducing Losses in Transmitter Leg

Single stubs have been successfully placed between the repeater's *exciter* and the *final amplifier* in an effort to reduce **exciter noise**.

Using this technique the losses normally incurred at the higher power when *all* the notch stubs are placed inline with the *output* of the final amplifier will be seen at the lower power level of the exciter. This can reduce losses in the transmit leg (and at the transmit power level!) by 1/2 a dB or more.

3.5 Repeater split consideration

We favor the 1/2 MHz split because antennas can be nearly "in tune" for both receive and transmit frequencies. At 52.50 MHz a 2% frequency spread is 1.05 MHz. This means the Standing Wave Ratio should be less than 1.5 over this 1.05 MHz range and the RL (Return Loss - reflected power loss) should be around 14 dB.

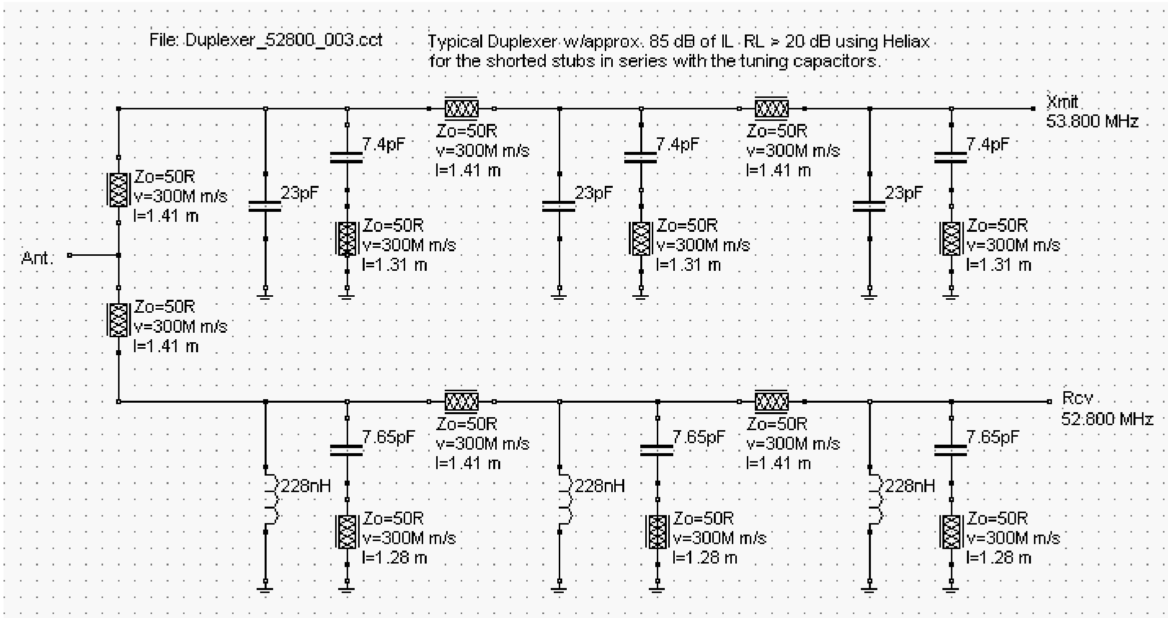
The one-half MHz spacing of 1/2 MHz split machine is well within the 2% frequency spread spec'd for most commercial antennas at six meters where the SWR is specified to be less than 1.5 (14 dB RL). Operating (centering) a 1/2 MHz split repeater as close to the center of this bandwidth should yield an SWR below 1.2 (about a 21 dB RL).

This says nothing of where the actual antenna impedance (Real + Imaginary) may lie on the Smith chart though. The *actual mismatch loss* could be much larger because a non-conjugal match could exist between the output of your duplexer and the antenna. As these Z values are highly field dependent on a number of factors trial and error with appropriate test equipment may be necessary for total optimization.

3.6 Sketches, Images

Schematic diagram of typical duplexer

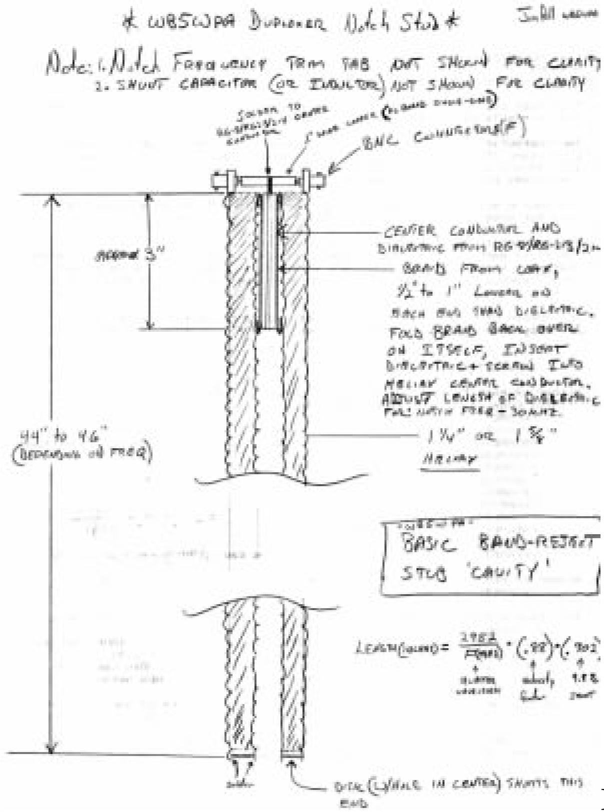
Note: a) nominal component values are shown b) exact component values vary with design c) individual designs require tuning with RF instruments, d) lengths of transmission lines are in meters, e) receive and transmit frequencies are as indicated.



A sketch from my early *crude* notes - schematic diagram of duplexer: [Schematic sketch (.gif image)]

- -

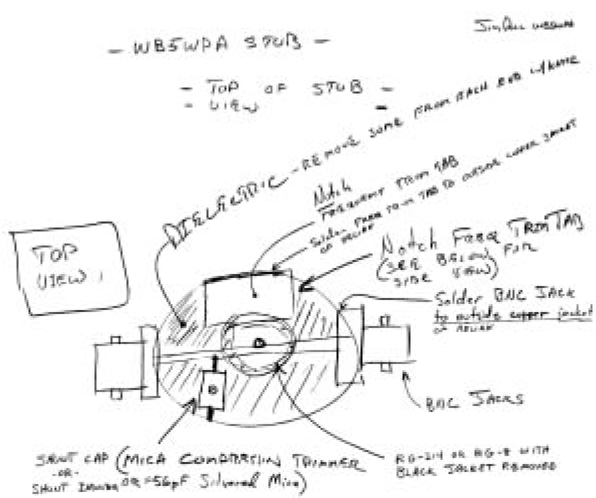
Cutaway diagram of one stub (product of early work circa 1991).



Large, detailed view: [cutaway view sketch (Acrobat Reader PDF format)]

- -

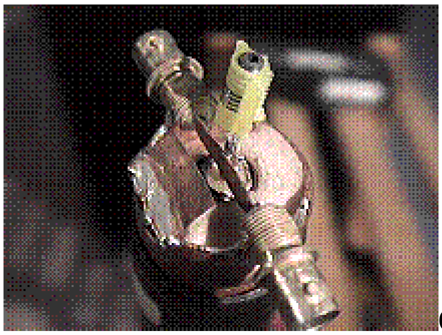
Top view; Close up of early work (circa 1991) showing the top of the stub.



Large, detailed view: [Top view sketch (Acrobat Reader PDF format)]

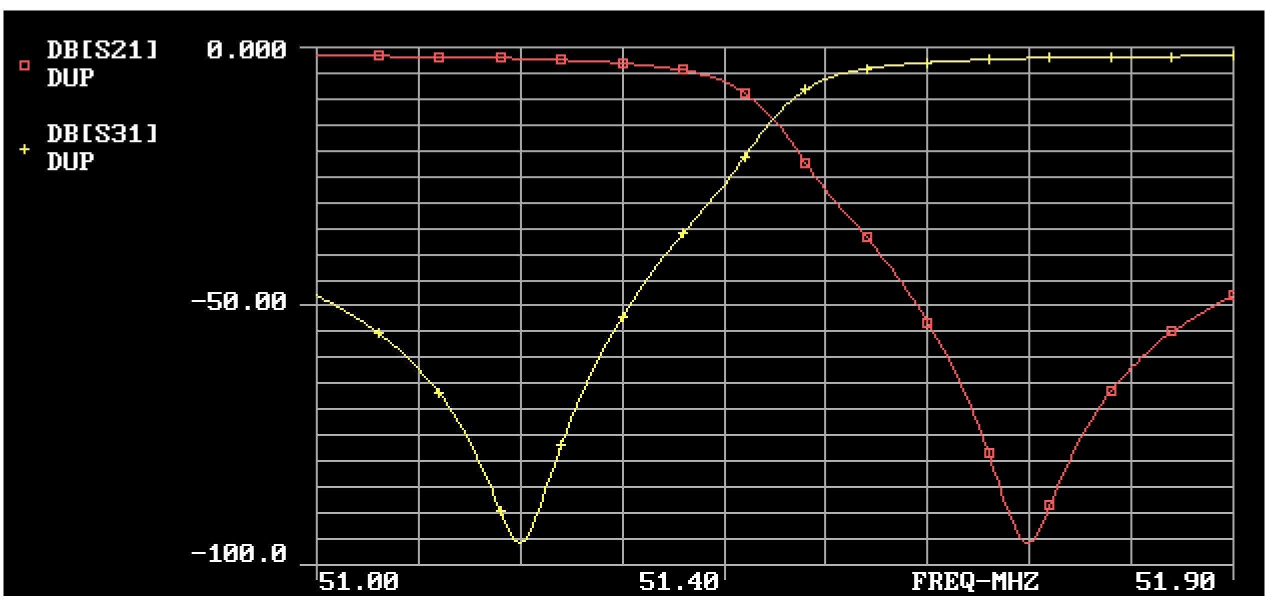
- -

Close-up views of early-work (circa 1991) showing the top of a stub with an inductor. A Mica compression would replace the inductor on the other stubs as required.

Other pics: gif 1 , gif 2 , gif 3a , gif 4a , gif 5a

---

3.7 RF Sweep



Rcv/Xmit leg RF performance of a 1/2 MHz split, 95 dB isolation 1 5/8" Heliax duplexer.

Full-size graph depicting the IL performance of an 85 dB Isolation, 1 MHz split duplexer: Receive leg, Transmit leg. These were taken from the antenna port through each of the legs to the receive port and transmit port respectively - and depicts the IL (S21) from each of the legs (transmit and receive) back to the common antenna port.

Full-size graph depicting the isolation performance of the 85 dB 1 MHz split duplexer. This is taken from the transmit leg to the receive leg and depicts the isolation (measured via an IL or S21 measurement) the duplexer provides between receiver to transmitter with the antenna port terminated in a resistive or "50 + j0" (pronounced "fifty jay zero") Ohm load.

Duplexer design, website issues, or to have a duplexer built for use on your **VHF low-band commercial** (30 - 50 MHz) repeater or for the **6M Amateur** band **e-mail Jim** (call sign: WB5WPA) at "**jvpoll at dallas -dot- net**" (Be sure to remove the at and -dot- and spaces and replace as required).

History:

Dan, N5MRG, at one time was *building duplexers*. (All of Dan's units were fabricated using 1 5/8" Heliax and are **Plug and Play** -no external tuning required- units.) Please note that what Dan built differed *physically* from what is shown here but electrically were identical.The changes/improvements he made were for producability and ruggedness (you might call the units he built **second generation units**!) - considerations not implemented during ***initial proof-of-concept and engineering development*** of the first duplexer I built and subsequently describe in detail on this page.

Present day:

Since Dan has been busy lately with other projects I volunteered to build units for those simply wanting units already constructed. The product of this effort resulted in a compact, closed-top design that can be seen at the top of this page.

In this compact, closed-top design the coaxial cable that is used to interconnect the 'stubs' (as well provide the duplexer's input and output connection cables) are ***soldered in place*** on the stubs - this works to solve a couple of small problems that can occur in time over the life of equipment:

- a) Fewer connectors to clean - or keep clean during PM (preventative maintenance) activities - there are only four (4) BNC connectors (excluding the BNC tee that is used to join the receive and transmit legs to the common antenna junction). Compare that with a total of ***12 connector pairs*** (24 individual connectors; 12 male and 12 female) dedicated to stub connections alone on a conventional 'fully-connectored' design *plus* the 2 connectors present on the cables at the BNC Tee junction ... compare that again to only -4- connectors present on compact, closed-top design that I build (ignoring the mating BNC Tee in each case).

- b) ZERO chance of someone 'borrowing' *one of your nice BNC-connectored 36" interconnecting cables* for some other purpose (not everyone enjoys exclusive access to their own repeater 'hut' at the base of a tower or on a mountain top!)