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The AM Brick-Wall 160 Meter Filter

Presenting "The *Original* North-Central Texas AM-Broadcast-Band BrickWall Filter"

The North Central Texas AM Brickwall Filter was built at the request of a friend and fellow ham who lives *just miles* from a 10,000 Watt expanded AM broadcast band station (KTBK) here in Texas operating at 1700 KHz - the *top channel slot* in that expanded spectrum.. I think he also has, off about 10 miles to his east, another medium power AM station at 620 KHz. Development with hand-wound air-core coils began in the summer of 2002. The first public appearance on this web page was in 2005.

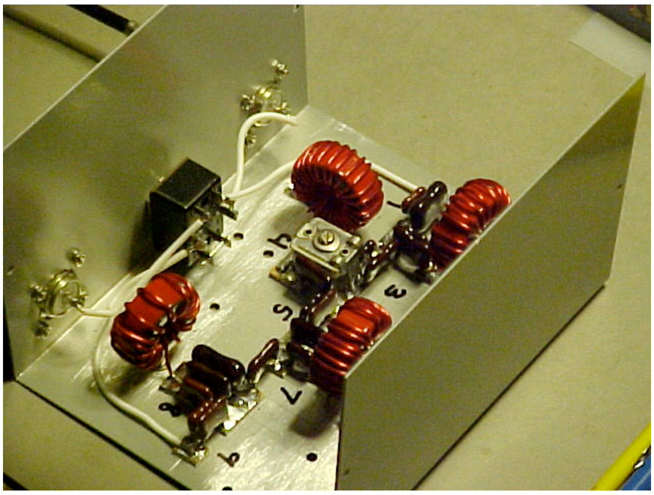
This filter allowed my fellow ham to work 160 Meters - all of 160 Meters, including the CW portion of the band right down to 1800 KHz - without the debilitating effects normally experienced by his receiver due to overload from the strong commercial AM broadcast band signals present at his QTH located in North central Texas.

AM Radio location studies, a plot of radio stations in selected areas where this filter was tried:

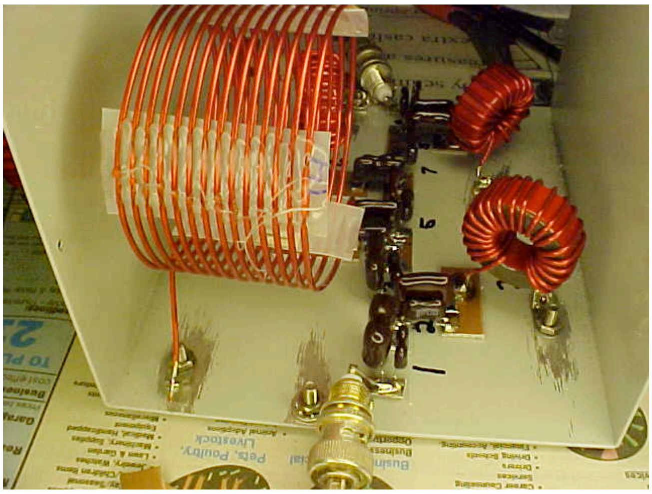
- AM Radio Station study - Washington, DC (See also an animation of the AM Brickwall 160 M Filter performance via spectrum analyzer pictures taken from this location by W3DQ.)
- AM Radio Station study - Reading, Ma.
- AM Radio Station study - Reno, Nevada (I never heard back from Harold near Reno so I assume he loves this filter; he never did respond how it worked.)

This filter may alternatively be called, on account of its function and purpose in life:

o The North-Central Texas AM-Band Brick-Wall Broadcast Filter
o The North-Central Texas AM Brick-Wall AM Broadcast-Band Filter
o The North-Central Texas Brick-Wall AM-Band Filter
o The North Central Texas 160 M Brickwall Filter
o The North Central Texas AM Brickwall Filter
o The AM BrickWall 160 Meter Filter
o The AM-Band Blocker
o The AM-Band Blocker High Pass 160 Meter Filter



Toroid version of prototype of the "The AM BrickWall".



Early prototype with air-core coil circa 2002.

Features:

- Connects in-line with any 160 through 10 Meter (1.8 through 30 MHz) HF transceiver - transmit right through it on any HF ham band above 1.8 MHz!
- Compatible with output from a typical 100 Watt class HF transceiver
  - The filter is designed to be a "50 Ohm component"
  - Suitable for inserting between a) a radio and an amplifier or b) a radio and a tuner
- **Attenuates ALL signals** in the AM broadcast - with a spec'd minimum 40 dB of attenuation **beginning at 1700 KHz** (the highest allocated frequency in the expanded AM spectrum in the USA)
  - Reduces *all* AM Broadcast transmissions by a power reduction ratio of *at least* 10,000:1
  - Effectively reduces a 10,000 Watt AM Broadcast transmission to *at most* 1 Watt (spec'd minimum of 40 dB of attenuation)
  - Effectively reduces a 50,000 Watt AM Broadcast transmission to *at most* 5 Watts (spec'd minimum of 40 dB of attenuation)
- Totally passive design - Intrinsic T/R (Transmit/Receive) operation
  - No moving parts
  - Uses no relays (no contacts to 'get dirty')
  - Requires no connection to a power source
  - 'Instantly' switches from transmit to receive and back again - no relay time delays to contend with
- Bypass switch allows quick and easy, in/out performance verification or 'checks'

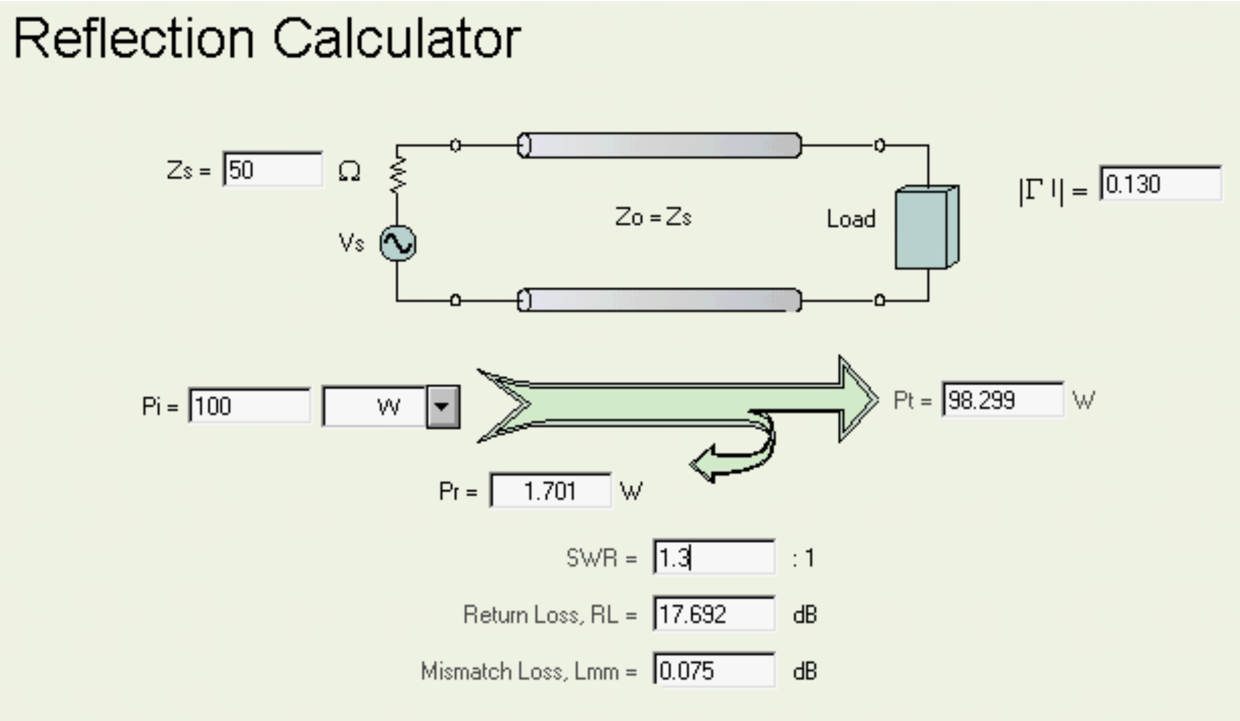
Electrical Performance - 'the numbers'

- Attenuation of the ENTIRE US domestic AM Broadcast band (including the e*xpanded portion of the AM broadcast band from 1.6 to 1.7 MHz)*
    - 40 dB minimum *beginning at* 1702 kHz and extending down into and across *the entire AM broadcast band*
    - Equivalent to *2* normal **RF Attenuators** (nominally 20 dB each) 'switched in' *for the AM Broadcast signals *only*
- 160 Meter band performance
    - The initial 'conservative' numbers based on circuit simulations and an early prototype:
        - Low-band (1800 KHz) insertion loss - less than .8 dB
        - 1820 KHz insertion loss typically less than 0.7 dB
        - Mid and high-band (1900 - 2000 KHz) insertion loss - less than 0.5 dB (typically .4 dB or less)
        - VSWR better than 1.30, typically 1.2:1
    - The 'real' (measured) numbers, based on the construction of a number of prototypes:
        - 1.800 MHz 0.65 dB
        - 1.805 MHz 0.60 dB
        - 1.820 MHz 0.50 dB
        - 1.850 MHz 0.40 dB
        - 1.900 MHz 0.30 dB
        - SWR - better than 20 dB Return Loss or 1.22:1 VSWR
- Above 160 Meters (HF spectrum from 3.5 to 30 MHz) insertion loss
    - IL Loss (above 3.5 MHz) less than 0.2 dB
    - SWR (or 'VSWR') (above 3.5 MHz) better than 1.2:1

A Word about SWR (or 'VSWR'), Return Loss, and what that means

The following screen shot was taken of HP's AppCAD (Version 3.0.2) Reflection Calculater. It shows the relationship between Rho (Reflection Coefficient), SWR (Standing Wave Ratio), Return Loss (abbreviated most often simply as 'RL') and Mismatch Loss (Lmm) for an SWR ratio of 1.3:1. As can be seen, for an SWR of 1.3 (to 1) this results in 1.7 Watts of 'reflected power' for 100 Watts of incident or '*forward power*'.

The loss of the 1.7 Watts reflected power translates to a *mismatch loss* (Lmm) of .075 dB ... resulting in 98.3 Watts being delivered to the load (nominally, 'the antenna').

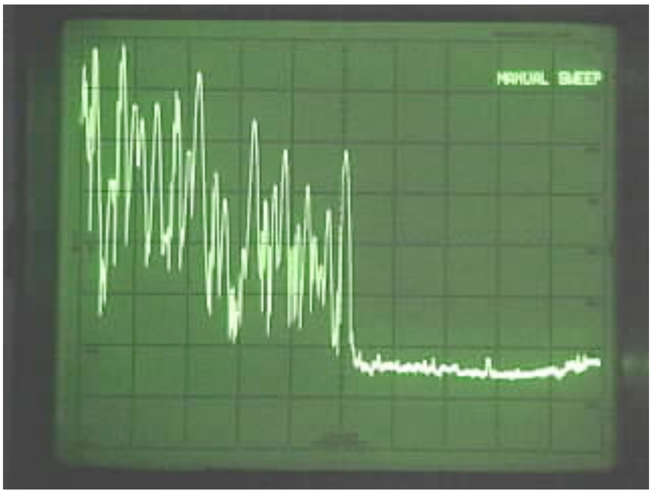


The AM-Band BrickWall Broadcast Filter Performance

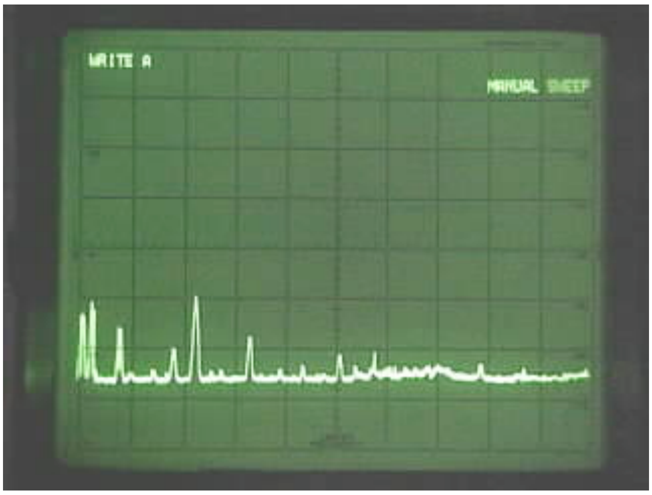
Here is an animation of the AM Brickwall 160 M Filter performance taken using a spectrum analyzer from north of Washington DC just 4.4 miles from radio station WTOP at 1500 kHz and 50,000 Watts and an omni pattern.

Below is the AM Brickwall Filter response from a location north of Dallas (Dallas/Ft. Worth metro area). The two Spectrum Analyzer CRT displays show the amplitude response from about .7 MHz through 2.7 MHz at 200 KHz/division. This display shows the "before and after attenuation" - the 'without and with' spectrum and demonstrates how effective the AM BrickWall Filter is in attenuating signals in the AM Broadcast band while exhibiting minimal insertion loss to the 160 Meter band frequencies (1.8 MHz and above).

The leftmost five divisions represent the top half of the AM Broadcast band from about .7 through 1.7 MHz; the center is exactly 1.7 MHz and shows the signal present at my QTH from a 10,000 Watt omnidirectional 1.700 MHz station located here in North Central Texas. The 160 Meter band (1.80 - 2.0 MHz) starts in the middle of division six (counting from the left).



Without Brickwall filter



With Brickwall filter!

Insertion loss in the 160 Meter band is less than .8 dB at the very low end of the band (1.8 MHz) and less than .5 dB at the high end (2.0 MHz) of the band.

Notes: An active antenna was used to obtain live off-the-air signals for this demonstration. This particular active antenna itself is relatively immune - contributes relatively little to 'intermodulation' products which result from the multitude of strong signals present due to the numerous AM Broadcast sites in and around the DFW area. By contrast, the old Radio Shack DX-302 I use for some testing *must* be operated with 20 dB of attenuation switched-in when near the AM Broacast Band - unless the AM Brickwall Filter is placed in-line that is!

Comparison with Competing products

160 M Bandpass Filters, BCB Highpass 'Interference' Filters

There are for sale today several very fine products that are built to reduce interference (notably, very strong signals) which emanate from commercial AM broadcast services in what has come to be known as "the AM Broadcast band" here in the United States. Today that band extends up to 1.700 MHz (the last 'authorized' station in the AM broadcast band has a carrier frequency of 1.700 MHz - sidebands extend up a few kilohertz from there).

Here is a short, and hopefully representative, list of filters currently available:

1a) Transmit capable filters, BandPass:

- Bandpass filter, 160 Meter: W3NQN Single Band Transceiver Bandpass Filters
  - Range: 160 Meter band only (1.8 MHz - 2.0 MHz)
  - Performance: Only about 3 dB attenuation at 1.700 MHz and 15-16 dB at 1.5 MHz
  - 40 dB down point approximately 1.100 KHz

1b) Transmit capable filters, HighPass:

- High pass filter, BCB Interference Filter ICE (Industrial Communications Engineers, LTD) Model 402X
  - Range: 160 Meters to ??? (1.8 MHz to ???) (upper frequency limit not specified)
  - Performance: Only about 8 dB attenuation at 1.700 MHz and 20 dB at 1.5 MHz
  - SWR not specified

- ***The North-Central Texas AM-Band Brick-Wall Broadcast Filter***
  - Range: 160 Meters through 10 Meters (1.8 MHz to 30 MHz)
  - Performance: 40 dB attenuation at 1.703 MHz and below (this means 40 dB or greater at 1.5 MHz, etc.)
  - SWR is less than 1.30 to 1 starting at 1.800 MHz
  - SWR is less than 1.10 to 1 above 3.500 MHz

2) Receive only filters:

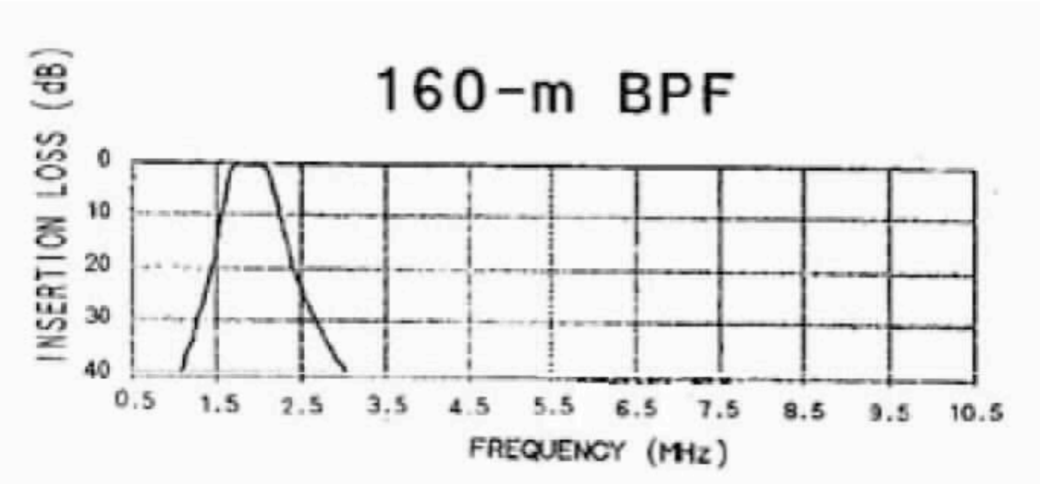
High pass, receive only: Par BCST-HPF

The W3NQN 160 Meter Bandpass filter

The W3NQN 160 Meter Bandpass filter exhibits performance as shown in the following figure. I have every confidence this filter lives up to the performance specifications advertised. If a bandpass filter function is what you need with the center bandpass frequency centered on the 160 M band within the performance envelope shown - this filter is clearly for you.

Now on to analyzing a few performance characteristic on the W3NQN 160 Meter bandpass filter:

- The attenuation of this filter at 1.7 MHz appears to be something less than 5 dB - perhaps on the order of 3 dB (3 dB is what I estimate when if I blow the graph up in size and visualize where the performance curve crosses an imaginary 1.7 MHz marker line).
- Notice the performance at 1.5 MHz - I estimate 15, maybe 16 dB of attenuation where the attenuation curve crosses the vertical line denoting 1.5 MHz on the graph. By contrast, *The North-Central Texas AM-Band Brick-Wall Broadcast Filter* will exhibit a minimum of 40 dB at this point.
- I also estimate that the 40 dB down point on this 160 M BP Filter as being approximately 1.100 KHz - the *The North-Central Texas AM-Band Brick-Wall Broadcast Filter* has been delivering *at least* 40 dB of attenuation long before this point.

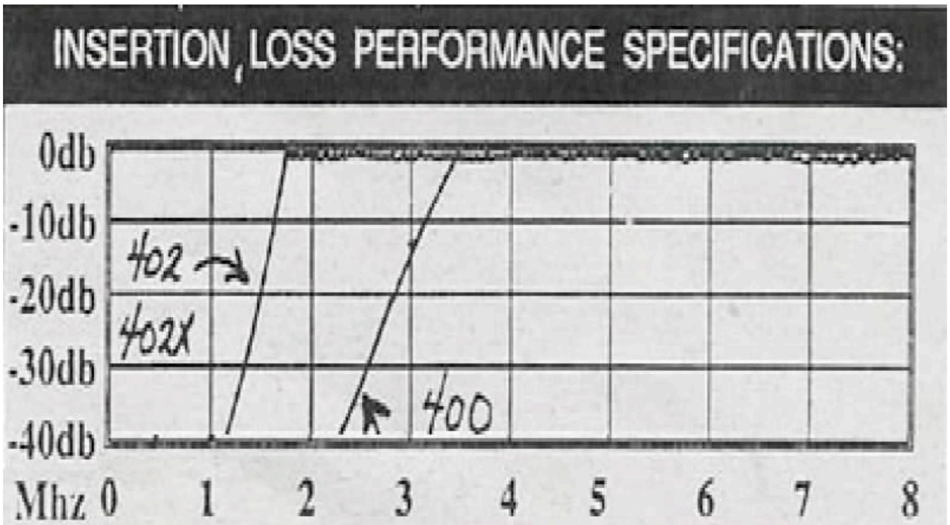


The ICE Model 402X Highpass Filter

This filter is a little more loosely "spec'd", shall I say. Below in the figure is a graph denoting this filter's characteristics up to the point where it exhibits 40 dB of attenuation.

- I estimate the attenuation (the IL) at 1.7 MHz to be something over 5 dB and certainly less than 10 dB; I shall peg it to be 7 or 8 dB.
- At 1100 KHz the attenuation finally approaches 40 dB
- There are no SWR ('VSWR' or RL) specs that I can see on the web site where this filter is displayed.

Real-world filters do not exhibit the 'clean' cutoff curves depicted below, so, one might expect that the Insertion Loss on the low end of 160 Meters (1.8 MHz) could to be a dB or so with a correspondingly adverse SWR of perhaps 1.7 to 1. Perhaps the IL is not that bad and the SWR is not as bad as I extrapolate ...

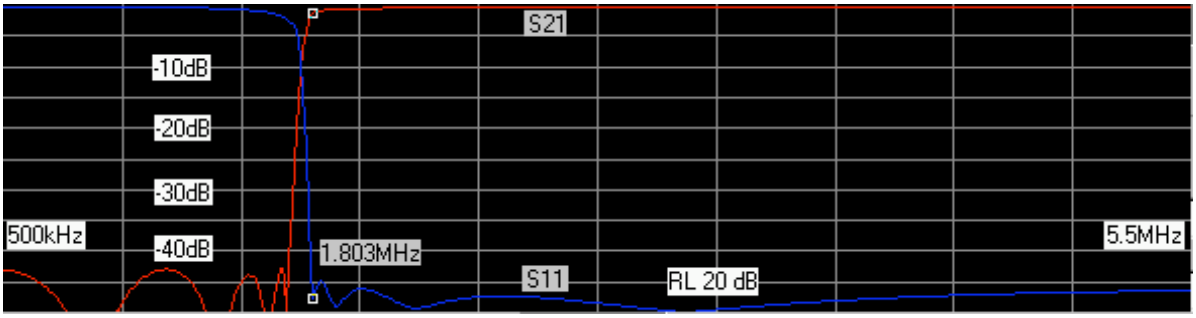


The North-Central Texas AM-Band Brick-Wall Broadcast Filter

Below is a representation of the IL (S_{21}) and RL (S_{11}) swept performance of the AM-Band Brick-Wall Filter. This representative sweep is from 500 KHz (on the far left side of the graph) through 5.5 Mhz (on the far right side of the graph).

- Notice the near razor-sharp cutoff that occurs between 1.7 MHz and 1.8 MHz - this 'cutoff' exceeds 40dB at and below 1.7 MHz.

Given the sweep range of .5 - 5.5 MHz the horizontal scale for this sweep works out to 500 KHz/division resulting in horizontal scale 'tick' marks every 1/2 MHz resulting in a scale beginning at 0.5 MHz (far left) followed by 1.0 MHz, 1.5 MHz, 2.0 MHz, 2.5 MHz and so on up to 5.5 MHz (far right).



Below are two figures that more closely depict the AM Brickwall Filter's performance in and around the 160 Meter and AM Broadcast bands. These 'plots' are screen captures from RFSim99 and very closely resemble the actual performance of a real *North-Central Texas AM-Band Brick-Wall Broadcast Filter* - it's just too cumbersome to record a couple of hundred data points by hand and enter them into a spreadsheet for display so I shall use the a screen capture of the results of a modeling run produced by RFSim99.

In the figures below, note that:

- The 1st figure has the 'marker' placed at 1.7 MHz and the second figure has the marker placed at 1.8 MHz.
- The Start and Stop sweep frequencies, as indicated in the start and stop parameter windows are 1.5 and 2.0 MHz respectively resulting in a horizontal scale of 50 KHz per division.
- The center of the graph (where Blue and Red lines cross) therefore represents 1.75 MHz.
- The 'Red line' on the graph indicates S_{21} (or Insertion Loss) and works with the left scale - it is marked in 5 dB graduations.
- The Blue line indicates S_{11} (or Rho or Reflection Coefficient and relates to the SWR/Return Loss values) and works with the right scale which is set for 0.1 per division. A Rho value of 0.1 corresponds to a RL (Return Loss) value of 20 dB and an SWR of 1.22:1. A Rho value of 0.2 would indicate an SWR value of 1.5:1.

This figure directly below shows an attenuation of 44.45 dB at 1.7 MHz - this is the highest allocated channel in the AM broadcast band at present. Notice that everything below 1.7 MHz is better than 40 dB 'down'.

Marker showing performance at 1700 KHz

This figure shows the IL (Insertion Loss) performance and Rho (Reflection Coefficient) at 1.8 MHz. Notice that at 1.8 MHz S_{21} (the IL) equals 0.8 dB and Rho equals 0.06 (equating to an SWR of 1.13 to 1):

Marker showing performance at 1800 KHz