HIGHPOINT SECURITY TECHNOLOGIES Inc.

White Paper

500 – 1500 MHz RF Amplifier Design

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The following paper will describe the design of an RF amplifier with a pass band of 500MHz to 1500MHz, using a Mini-Circuits ERA-5 amplifier as the main building block. The ERA-5 amplifier has a bandwidth of DC to 4 GHz. For this reason input and output filters were used. The ERA-5 has a 1dB compression point of 18.4 dB and a gain of about 20dB in the pass band of the design. The insertion loss of the input filter is about 3 dB inside the pass band. Therefore the maximum input power should be limited to 0 dBm or 1mW.

The design consists of an input filter, the amplifier and an output filter. If a band pass filter with corners at 500 MHz and 1500 MHz is placed at the input and output of the amplifier, then out of band signals will be significantly reduced.

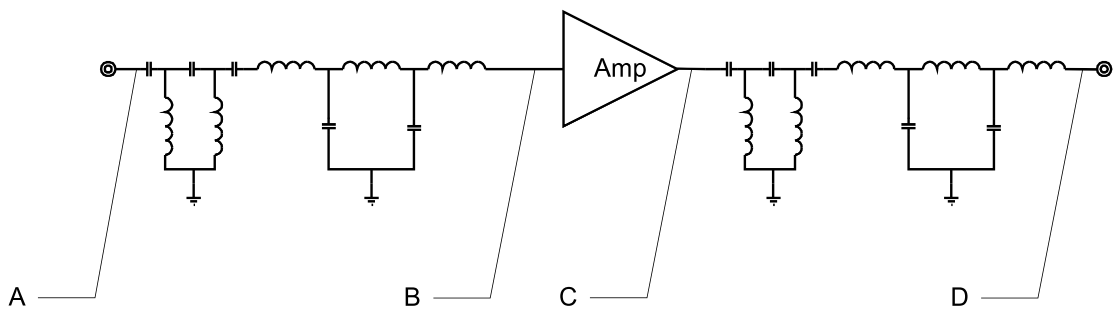

Figure 1 Block Diagram

Example:
Given two input signals, one at 950MHz and one at 150MHz [Point A].

If both signals have a power level of –20dBm, then the 150MHz signal will be attenuated by ~45dB by the input filter [Point B].

The power level of the 150MHz signal, at the input of the amplifier, will therefore be attenuated to -65dBm. The 950MHz signal is in-band and will not be attenuated. The amplifier has a gain of ~20dB. Therefore the output signal levels [Point C] will be –45dBm and 0dBm for the 150MHz and 950MHz signals, respectively. Therefore at the output of the amplifier the out of band rejection is 45dB.

If the same filter [Point D] is used on the output, then the 150MHz signal will be further reduced by 45dB. The result will be a 90dB of out of band rejection.

The first stage of the design involved the simulation and construction of the filters. The input and output filters are identical. The band-pass filter is actually a combination of a high-pass filter and a low-pass filter. This topology was used in order to make the component values sufficiently large to be practical. The basic filter is shown below in Figure 2.

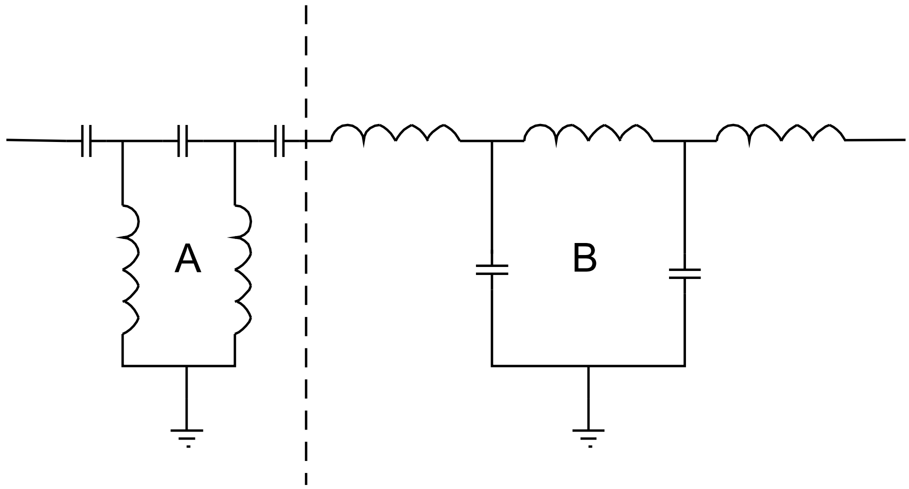

Figure 2 Basic Filter Design

Section A is the high pass portion of the filter while section B is the low pass portion. The two filters were simulated separately and then the two circuits were combined to form the filter above. This circuit was then simulated to confirm the design. The following graphs are the result of these simulations.

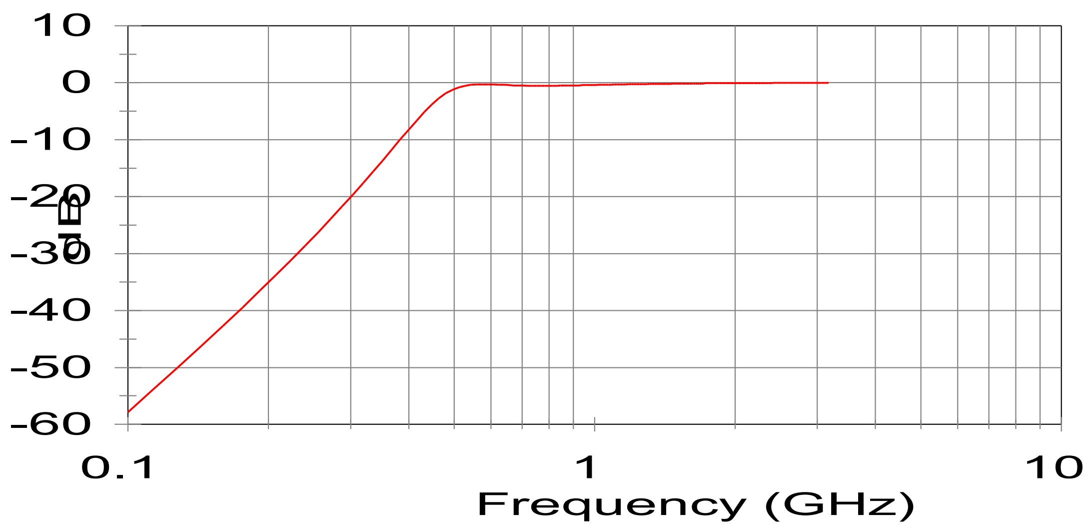

Figure 3 High Pass Filter Response

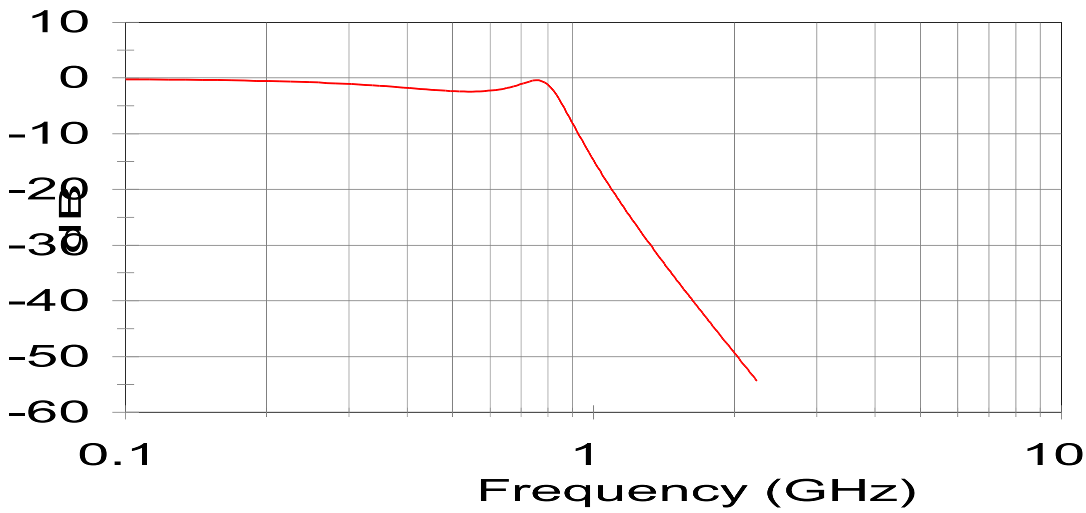

Figure 4 Low Pass Filter Response

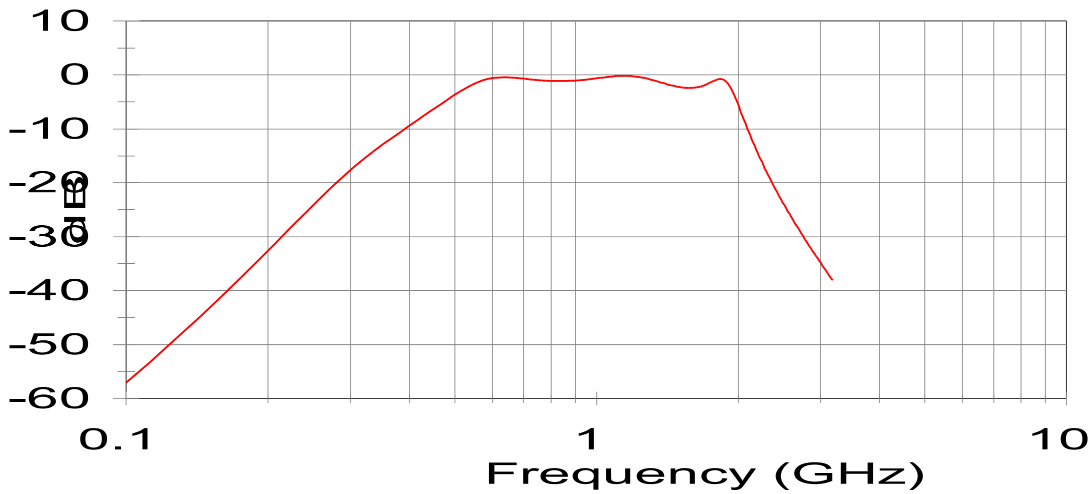

Figure 5 Band Pass Filter Response

In addition to making the component values manageable, this topology allows the design to be easily modified. The high or low frequency cut off values can be changed without affecting the other filter.

When the circuit was actually constructed and tested, there were some discrepancies between the simulation and the actual test results. This is no doubt due to component tolerances and parasitic inductance and capacitance associated with the actual construction of the PCB. Figure 6 below shows the S21 response of the amplifier.

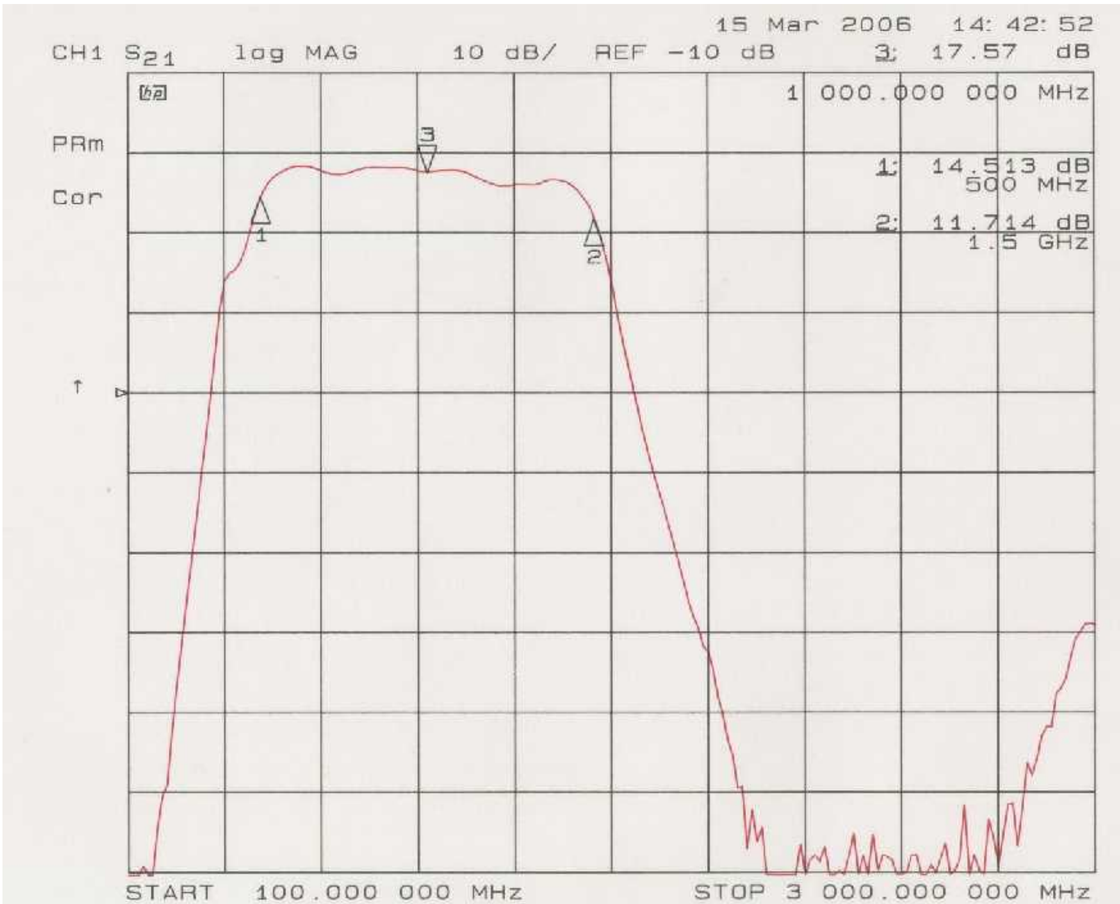

Figure 6 Measured S21 Response

Markers 1 and 2 above show the gain at the two corner frequencies. Marker 3 is the gain at mid-band. Note that the mid-band gain is over 17dB and the sharp slope resulting from the combination of the two fifth order band pass filters.

The markers were moved in Figure 7 below, to show the out of band signal rejection. Markers 1 and 3 show that this measurement is over 90dB.

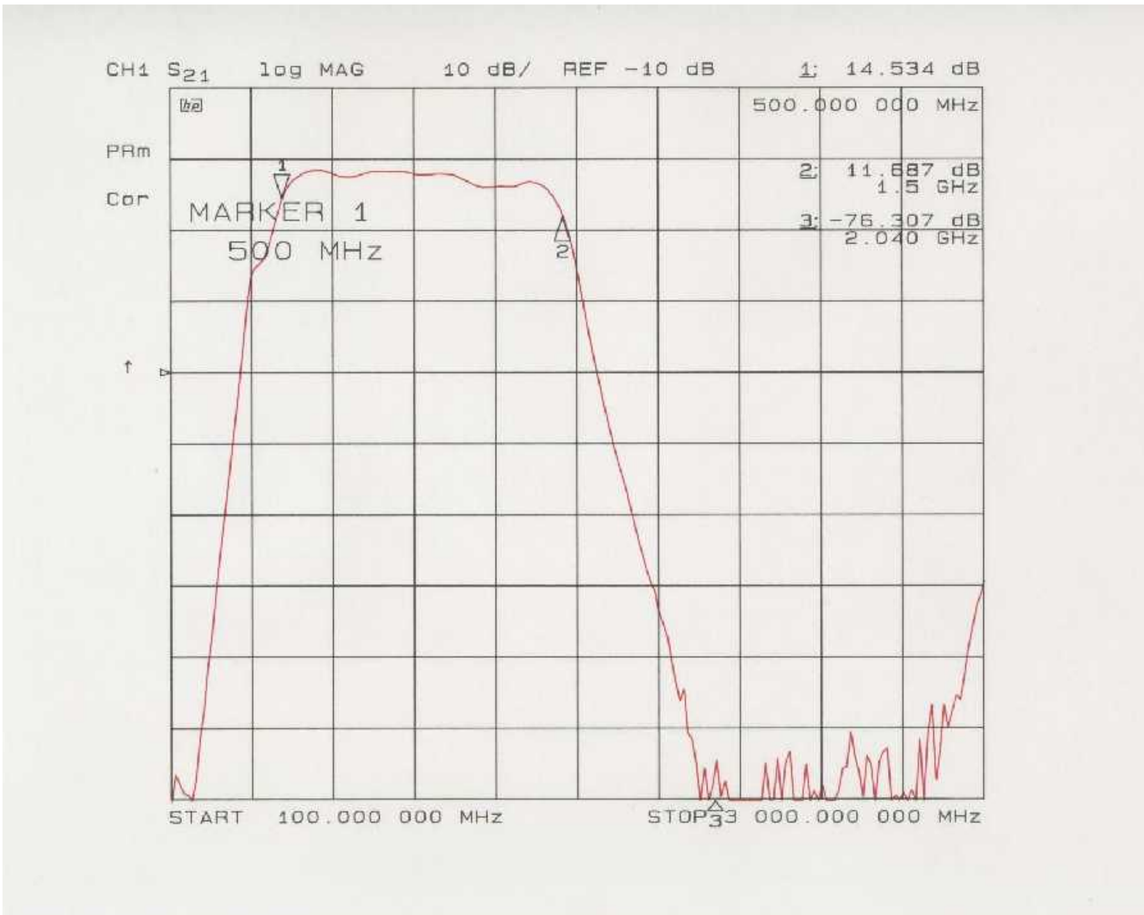

Figure 7 Out of Band Signal Rejection

The S12 or isolation of the amplifier was also measured. Figure 8 below shows the response. The in band isolation is approximately -33dB.

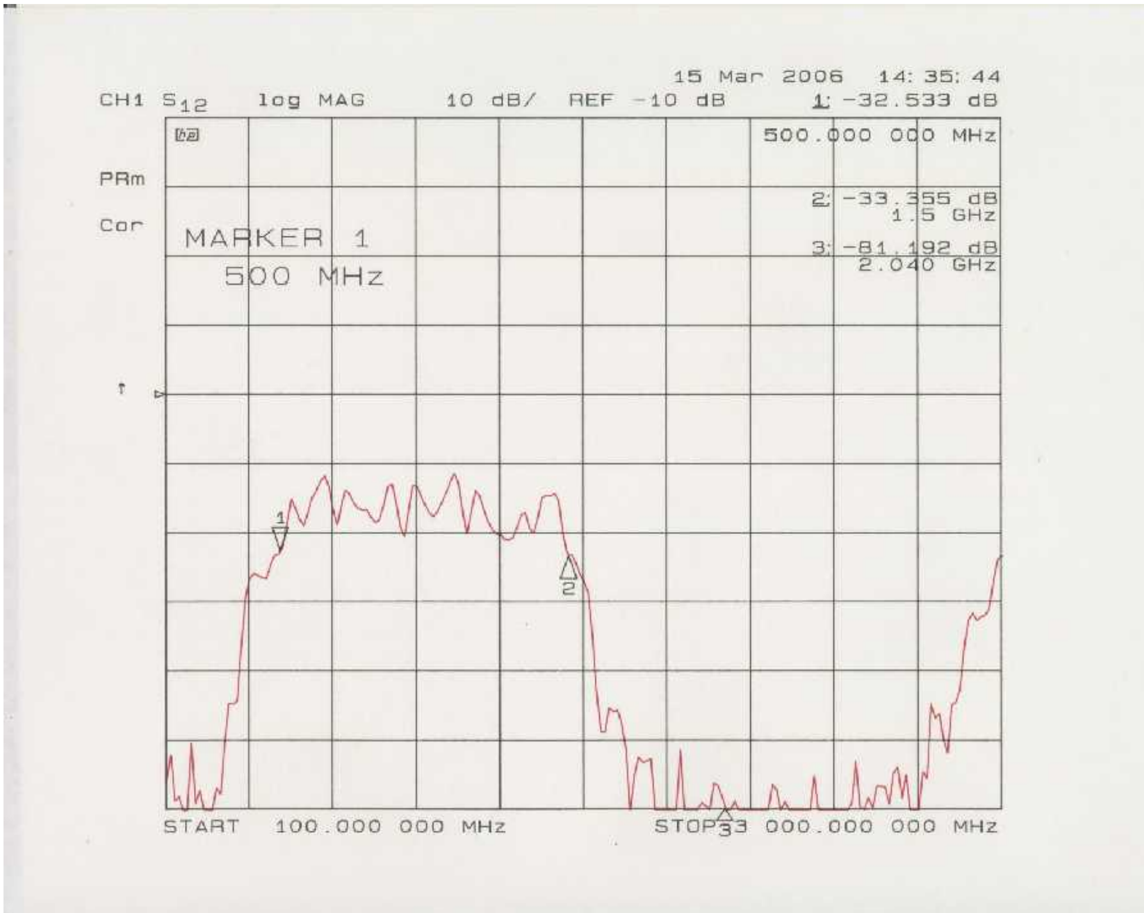

Figure 8 Measured S12 Response

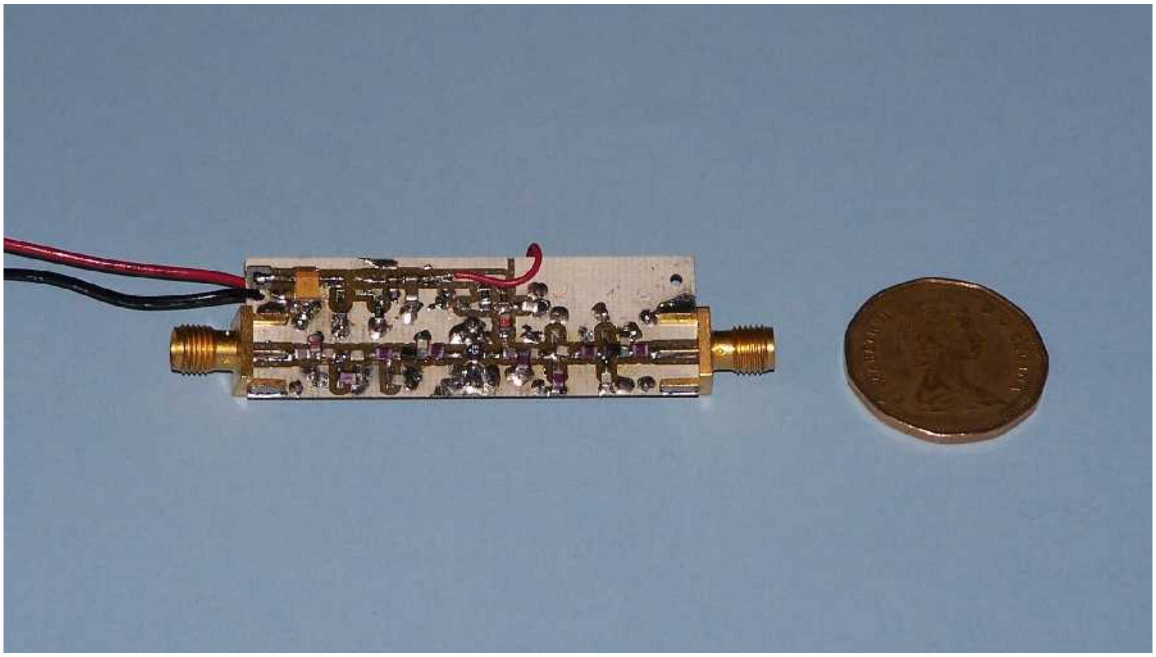

Figure 9 Prototype RF Amplifier

Figure 9 above shows the amplifier that was constructed and tested as the basis of this paper. Note the one-dollar Canadian coin used as a size comparison. This was not a commercial PCB and construction was hampered by the fact that the filter topology was changed after the prototype PCB was laid out. Surface mount components were used thru out the design, with the exception of the voltage regulator. The regulator originally used on this design had oscillation problems, so an LM317 regulator was built on a daughter board. The board is mounted to the back of the amplifier and cannot be seen in this picture. A new PCB was laid out which incorporates the new filter topology and the LM317 regulator. The amplifier PCB is designed to fit into a ¾" ID copper water pipe. If copper end caps of the same material are used then an RF tight enclosure could be constructed. The previously mentioned problems with the prototype made construction and assembly of this enclosure impossible.

This product is currently at the prototype stage. Further development will depend on the interest generated by this paper. The design is flexible enough to accommodate different power bandwidth ranges. For information regarding custom designs or production quantities, the reader should contact Highpoint Security Technologies at www.hipoint.ca for further information.

The input / output filter is also available separately from Highpoint. The filter PCB is designed to fit into a ½" ID copper pipe, much like the amplifier. Once again the reader should contact Highpoint regarding pricing and availability.

Amplifier Preliminary Specifications:

Power Consumption:	630mW (70mA from a 9VDC source)
RF Gain:	14dB minimum
Out of Band Rejection:	90dB
Isolation:	30dB minimum
Power Bandwidth:	500MHz to 1500MHz