# BOULDER TV Repeater's REPEATER

## December, 2018


Jim Andrews, KH6HTV, editor - kh6htv@arrl.net

**REPEATER STATUS:** Details about the repeater are available on our web site: www.kh6htv.com AN-43 gives all the technical details. If you have any questions about the current operations or status of the repeater, contact the asst. trustee, Don, N0YE.

**Future Newsletters:** If you have contributions for future newsletters, please send them to me. Jim Andrews, KH6HTV, email = kh6htv@arrl.net

**FREE DATV MAGAZINE:** There is a FREE !, monthly, international, on-line magazine for DATV hams. It is called ***CQ-DATV***. It is published by Ian, G8IQU and Trevor, G8CJS in the U.K. along with Terry, VK5TM, in Australia. The home page is: https://www.cq-datv.mobi/ All past 65 issues, dating from 2013, are available at: https://www.cq-datv.mobi/ebooks.php along with a few other ATV related items. If you would like to be on their e-mail mailing list and be advised when a new issue is posted, then go to their DATV News page and click on their "list" link. I have been recently asked to join their editorial staff and will be submitting technical articles based upon my many ATV / DTV application notes. Our newsletter is also shared with them and they have already published some of our local Boulder ATV news items.

## Correspondence Reference 70cm RFI on the TV Repeater Receiver:

Fri, 26 Oct, 1:30pm To: Boulder ATV Hams Subject: TV Repeater

Those ATV hams participating in the net yesterday can vouch for the fact that the TV repeater's 70cm receiver is "Blind & Deaf". No one could get into it at all.

It thus appears the repeater will need much more than a simple "house call" from the doctor. Instead, it needs to be trucked off in an ambulance (or at least an SUV) to an old folks home for some R&R along with de-lousing, repair, or whatever.

MY APOLOGIES — Sorry, but this is going to have to wait until next spring to happen. I simply do not have enough time left here in Boulder to start this major overhaul. I am heading off soon for my winter QTH in Hawaii. Work on the repeater will require removing the entire TV repeater rack of equipment from NCAR to my home workshop.

For now, you need to consider this to be strictly a cross-band repeater with input on 23cm and output on 70cm. It is still a functioning dual-mode repeater. either analog in / digital in and analog out /digital out..

We do however have a workable solution for those of you with only 70cm input capability. For Pete & Debbie, George & Doshia, and Steve, with 70cm DVB-T transmitters, we can use the solution that is now working routinely for Steve. That is for another Boulder ATV ham with 70cm receive and 23cm transmit capability to act as an intermediate relay point. Jack, K0HEH, now is doing this for Steve's signal from Sugarloaf Mountain.

For anyone wishing to help out as a 70cm in /23cm out relay station, I would suggest that you invest in an HDMI 1 in / 2 out active signal splitter. They are very low cost ($10-$20 range). You can find lots of them on Amazon and elsewhere by googling "HDMI 1 in 2 out". This way you can take the HDMI output from your DVB-T receiver and split it 2 ways. One to your home video monitor and the other as the A/V input to your Hi-Des DVB-T modulator. Nothing more required. If you are using the Hi-Des HV-100EH, you don't even need the splitter. Just attach your TV monitor to the HDMI output jack on the HV-100 box.

To accommodate Joe's 70cm, analog, VUSB-TV signal, I have been acting as his relay point recently. I have been using a CATV, analog TV receiver module to receive Joe's pictures. I have then patched the composite A/V from this receiver to the composite A/V inputs on the Hi-Des modulator and then relayed his picture on to the repeater on 23cm. I have asked Don, N0YE, to continue this service for Joe this winter. Don has agreed and I have passed on my CATV receiver to Don to use.

BATC Streaming — Larry has agreed to continue this service for the winter. He will soon be setting up a computer at his qth to stream the TV repeater's video to the BATC server. Larry's stream will be seen using his own call sign, K0PYX.

I hope to be able to participate in some of your weekly ATV nets from Hawaii. With Larry streaming the repeater video, I will be able to watch your videos. I should also be able to stream video myself and then someone of you here in Boulder could pick it up and put it into the TV repeater as my contribution. It will be interesting to try this out.

73 de Jim Andrews, KH6HTV

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Sunday, 28 Oct, 8pm, Boulder To: Boulder ATV Hams Subject: TV Repeater Status

GOOD NEWS ! The 70cm receiver is again working normally.

This afternoon, Don, N0YE, called me to report that he had just done some tests on the repeater and it appeared that the 70cm receiver was again working fine.

This evening, I have again also tested the repeater and confirmed that it is now back to normal. I was again able to access it with very low transmitter powers as follows:
23cm DVB-T = +4dBm
23cm FM-TV = -1dBm (P1) & +10dBm (P5/Q5)
70cm VUSB-TV = +5dBm (pep) (P1), +7dBm (P2), +17dBm (P3), +27dBm (P4) &, +37dBm (P5)
note: some RFI herringbone & occasional packet radio bursts seen for +27dBm or below
70cm DVB-T = +3dBm (normal encoding parameters) & -1dBm (very aggressive encoding)
note: in-band RFI raises freeze framing threshold by 18dB, need to be > +17dBm with aggressive encoding for error free reception
I have been running a continuous playing DVD for past 1 1/2 hours at +20dBm and getting great results on 70cm DVB-T.

Now the ?? — Why ? the change ?? Don & I both are scratching our heads about this. Several possibilities include:

1. The Arduino coding ? — perhaps there are certain sequences in which we punch in control codes that cause funky behavior, or total lock up?
2. RFI with D-Star repeater being on continuously for an extended period of time? It's transmit antenna is only a few horizontal feet away from our receive antenna. Need to be monitoring 70cm D-Star.
3. Intermittent connections ?

73 de Jim A, kh6htv

## ATV Repeater Interference

10-31-2018 -- from N0YE

The ATV repeater was active with 70cm DVB-T input on 441 MHz. The spectrum around 446 - 447 MHz was observed to correlate signals in that part of the spectrum and RFI on the ATV repeater. The observations were made around 3pm on 10-31-2018.

There were three signals observed when ATV interference was observed. The observations were made at the same time at the QTH of KH6HTV and the QTH of N0YE. Better observations should be made at the Mesa Labs.

The strongest signal observed was around 446.98 MHz. Another signal about 20 dB down in power relative to the above signal was around 446.75 MHz. These two signals tended to always appear together. There is a 70cm FM voice repeater assigned to K7PFJ in Boulder at 446.9875 MHz. There is a 70cm FM voice repeater assigned to N0SZ in Ft. Collins at 446.75 MHz. Both these repeaters are affiliated with The Rocky Mountain Ham Radio group and are likely linked. The 20 dB difference in power level correlates with one repeater being located in Boulder and the other repeater being located in Ft. Collins. These two signals were often present at the same time during the observation time of maybe 15 – 20 minutes.

A third signal was observed at about 446.86 MHz. This signal was seen only once. This signal was of the same signal strength at the 446.75 MHz signal. The D-Star 70cm transmitter output is on 446.8625 MHz and was undoubtedly this signal. This signal being located at the Mesa Labs will clearly be the most influential on the ATV repeater.

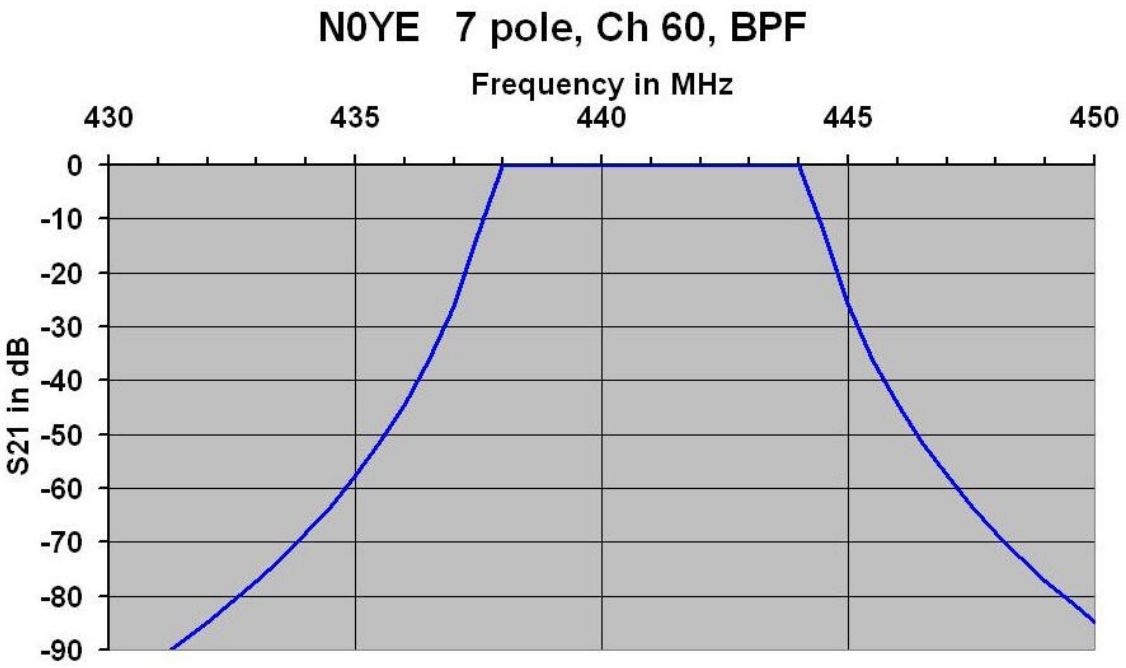
There may be other signals that could cause RFI to the ATV repeater input. More observations will need to be done to detect other possible interfering signals. What kind of filter do we need to deal with this RFI?

73 de Don, N0YE

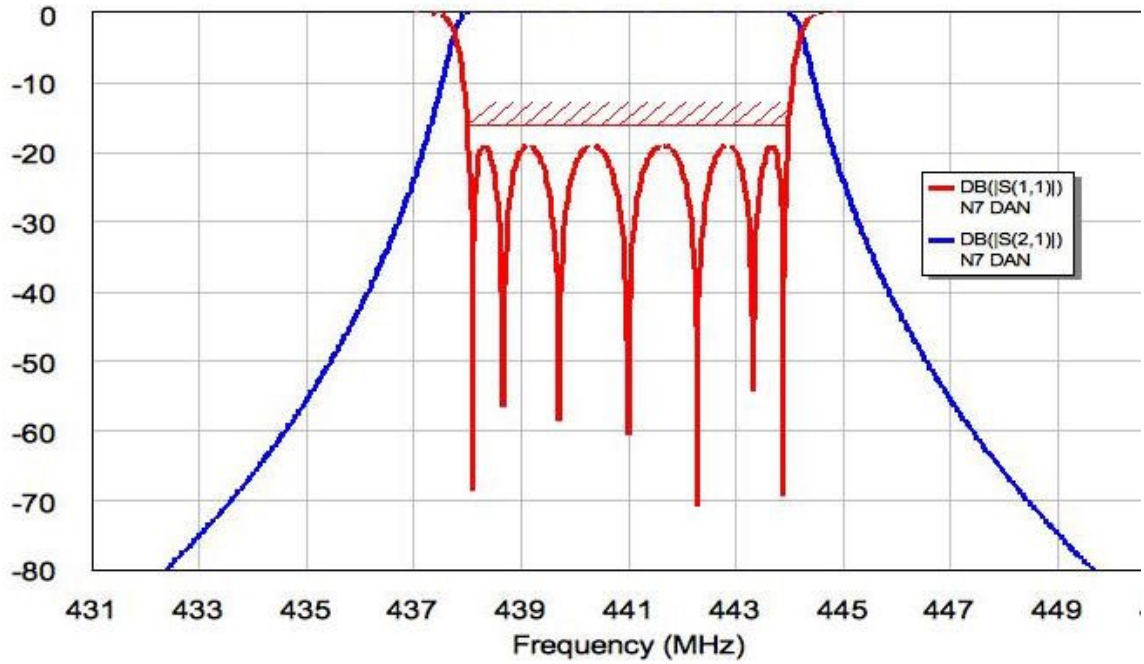
## New 70cm Band-Pass Filter Design

Don, N0YE, is proposing (16 Nov) that he build a new band-pass filter (BPF) for the TV repeater's 70cm receivers. He hopes this will help to minimize our 70cm RFI issues. The present filter is a very old Spectrum International, 5 pole, Ch. 60 filter which was used in the original TV repeater dating from the early 90s. Don has been observing the 70cm band activity with a spectrum analyzer and receivers. He has noted a particularly strong signal at about 447 MHz which could be one of the RFI sources for our repeater. He feels we need more skirt attenuation, particularly on the high side in the > 445MHz region. The present Ch 60 SI-BPF is giving us about -25dB of attenuation at 447 MHz. (see Fig. 5, p. 6 of my application note, AN-31 www.kh6htv.com ).

Don is proposing we go from a 5 pole to a 7 pole BPF. This will no doubt add a bit more in band insertion loss, but potentially a lot more skirt attenuation. Don is working with our resident filter expert, Dan Swanson, WB9AIA. Recall Dan gave a talk on filter design at a BARC meeting this past summer. Dan is a Fellow of the IEEE and a real expert on filter design. For more about Dan, see later in this newsletter.




Don made his first design pass using the free, on-line BPF design calculator from WA4DSY, (http://www.wa4dsy.net/cgi-bin/idbpf ) This was for a 7 pole, inter-digital BPF with a center frequency of 441 MHz, 0.1dB pass-band ripple, and 6.4 MHz -3dB bandwidth. The above plot of S21 vs. Frequency is the theoretical values predicted by WA4DSY's program. At 447 MHz, this filter would have about -58dB of insertion loss vs. the present -25dB of the SI-BPF. This is better than 2 X improvement ! ! !

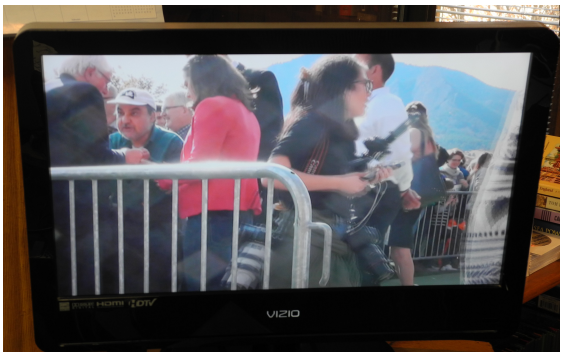



Dan has taken Don's WQ4DSY initial design and has done a computer analysis of it. Dan says "The WA4DSY software is not bad considering the price." (*note the price is $0*

*carefully read that as ZERO !* ). Dan's computer analysis showed the resonators are too long and the return loss, S11, was bad with poor location of the input/output taps. Dan has then run his own filter design program, called "***Cavity Interdigital***" or ***CID***. The above plot of S11 (red) & S21 (blue) shows his computed performance. The return loss is excellent at > -20dB. The S21 passband is flat. The predicted insertion loss at 447 MHz is about -55dB.

OK - Don, the next challenge is for you to now build a filter precisely per Dan's design ! ! Keep tuned to a future newsletter when we can report the results of Don's workshop. We hope it lives up to Dan's predictions.

Ch 58 - view of the crowd at rally



Ch 60 - Bernie Sanders (at left) shaking hands with crowd after his speech.

**BCARES in ACTION:** BCARES is called upon quite often to assist the University of Colorado Police Dept for major events occurring on the University of Colorado campus. The emphasis for the video provided to the CU police is to enhance crowd security by providing the police commander with "eyes in the field". An example of a recent event where BCARES assisted CU-PD was a political rally at CU featuring former Democratic presidential candidate, Bernie Sanders, as the key note speaker. BCARES had three TV cameras and DVB-T, 70cm, transmitters in operation for this event on channels 58 thru 60..

BCARES, since 1995, has been providing TV coverage for CU-PD of all the home football games. In the early days, their TV pictures were the only video CU-PD had and we had three roving teams going all over the stadium, both inside and out, along with a fixed camera location in the north end zone. This end zone camera with an extremely long telephoto lens could see +90% of all the spectators in the stadium and zoom into a single individual's face, if required. We had all access passes which allowed our TV crews to go anywhere in the stadium. We had, and still do, have our TV net control station in the police chief's command post. TV crews are dispatched on 2 meter FM to wherever needed. More recently, after the major remodel of the stadium, CU installed a large network of fixed, security TV cameras which now cover most all of the stadium. As a result, they no longer needed BCARES video in most locations. Today, BCARES typically provides only two camera teams that are used strictly outside of the stadium in areas not covered by the closed circuit, security cameras. The below photos are typical

scenes recorded by a BCARES camera outside of the main entrance gate on the Colorado Ave. entrance to the stadium.

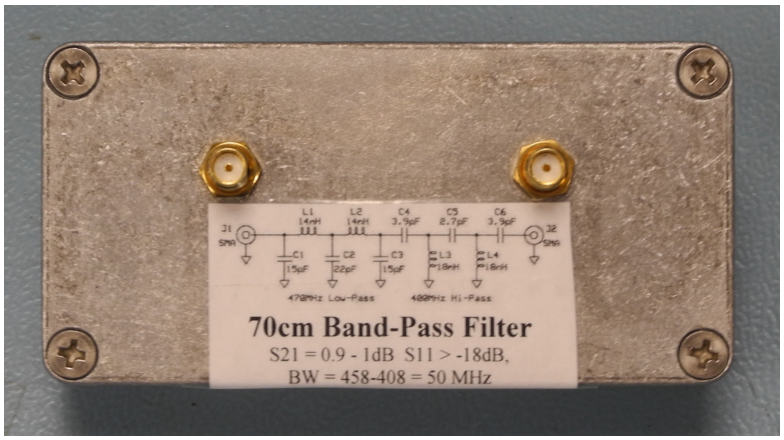


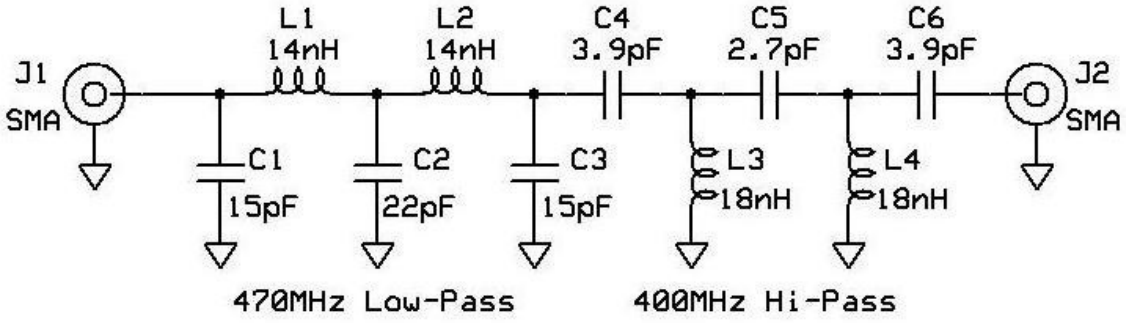
From 1995 - 2014, BCARES was using 70cm, analog, VUSB-TV transmitters. Each transmitter used an AM-TV transmitter along a Spectrum International, 6 MHz band-width, inter-digital, band-pass filter. We were thus able to field simultaneously, four TV cameras/transmitters on 70cm channels 57, 58, 59 & 60. The video was seldom broadcast quality. It usually was corrupted by multi-path, weak, snowy pictures and co-channel rfi. Well over 90% of the 2 meter FM voice traffic from net control were requests from net control to a camera crew to move their antenna a small distance to improve the picture ! Starting in 2015, BCARES switched over to using 70cm, DVB-T transmitters. They were thus able to eliminate the band-pass filters and reduce the weight carried in the back packs. They were still able to operated simultaneously on Channels 57 thru 60. The quality of the receive video immediately became broadcast quality, in high-definition. The requests from net control for camera teams to fine tune their antenna locations have all but completely disappeared. Now the net traffic is strictly dispatching and situation reporting. At TV net control in the police command post, BCARES has four separate 70cm TV receivers tuned to each of the channels 57 thru 60. Their A/V outputs are fed to a quad processor for display of all four images on a single large screen monitor for the police commander.

**70cm Band-Pass Filter:** I was having some issues with my 70cm receiver at home and thought perhaps a band-pass filter might help. I wanted to build a simple filter just using simple capacitors and inductors, not a mechanically complex filter, like the inter-digital filters Don, N0YE, builds. I didn't need a steep skirted, narrow band (6MHz) one like we use on the repeater, just one to cover the whole 30 MHz wide, 70cm band. Hopefully a flat response across the 70cm band and then relatively steep skirts with good insertion loss at 2 meters and 23cm.

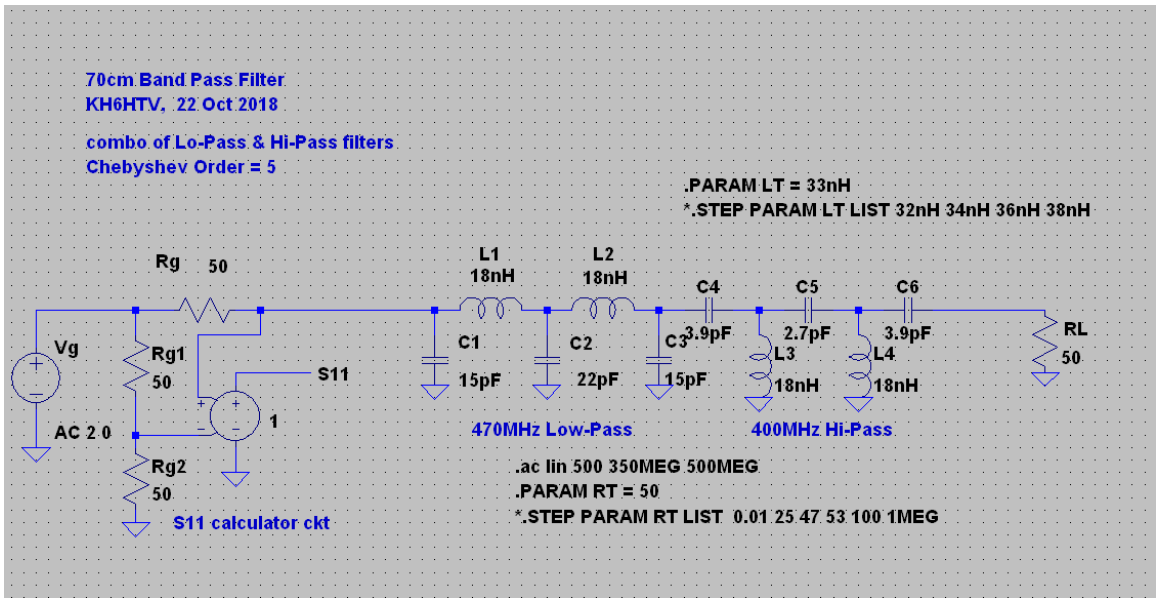
I first went to the internet and googled for a Chebyshev Band-Pass Filter (BPF) on-line calculator. Putting in my desired center frequency, bandwidth, etc. I got solutions, but they were not very realizable values. Very tiny inductors of less than 1 nH were required. My next approach was to instead use a combination of a 470 MHz, low-pass filter (LPF) and a 400 MHz, high-pass filter (HPF). This put the corner frequencies 20 MHz above

and below the 70cm band edges. I used 5th order filters for both the LPF & HPF. This gave solutions with realistic values for both capacitors and inductors.

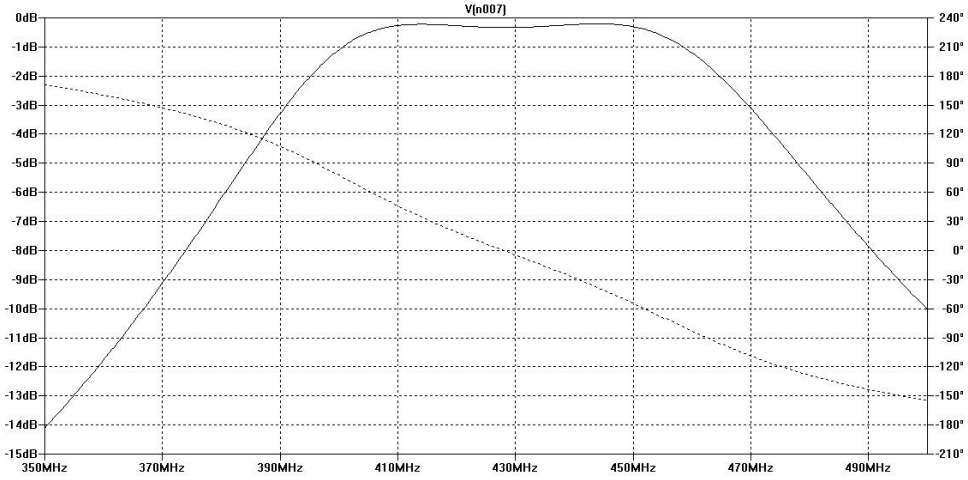


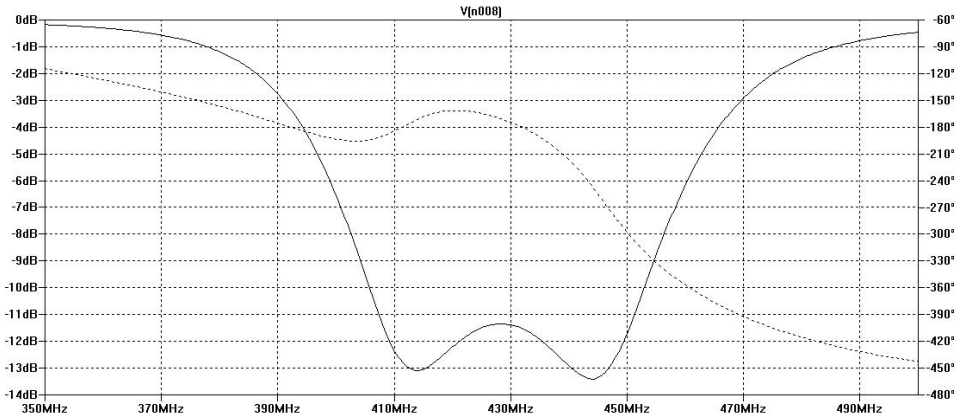

This is the resultant circuit diagram I used. The original design using the on-line calculators, called for all of the inductors to be 18nH. My next step was to take the combo LPF / HPF and use the circuit simulator program LT-Spice to calculate the theoretical frequency response for both insertion loss, S21 and return loss S11. LT-Spice is available free from Analog Devices.
https://www.analog.com/en/design-center/design-tools-and-calculators/ltspice-simulator.html



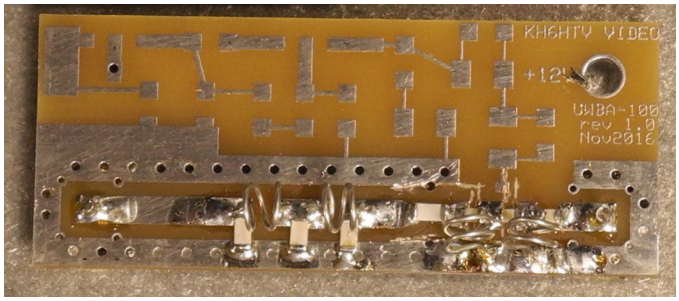

This is the LT-Spice circuit I used. The funny circuit on the left modeled the source, Vg & Rg, and a means of measuring S11. The following two plots show the LT-Spice simulation for S21 and S11 from 350 to 500MHz. IL = 0.3dB (430MHz), flat from 410 to 450MHz
-3dB BW = 471 - 390 MHz = 81MHz -65dB @ 145 MHz & 1270 MHz, RL = -11.4dB (430MHz), >11dB 410-450MHz




70cm BPF S21 Insertion Loss: 350 to 500 MHz, 1dB/div & 20MHz/div



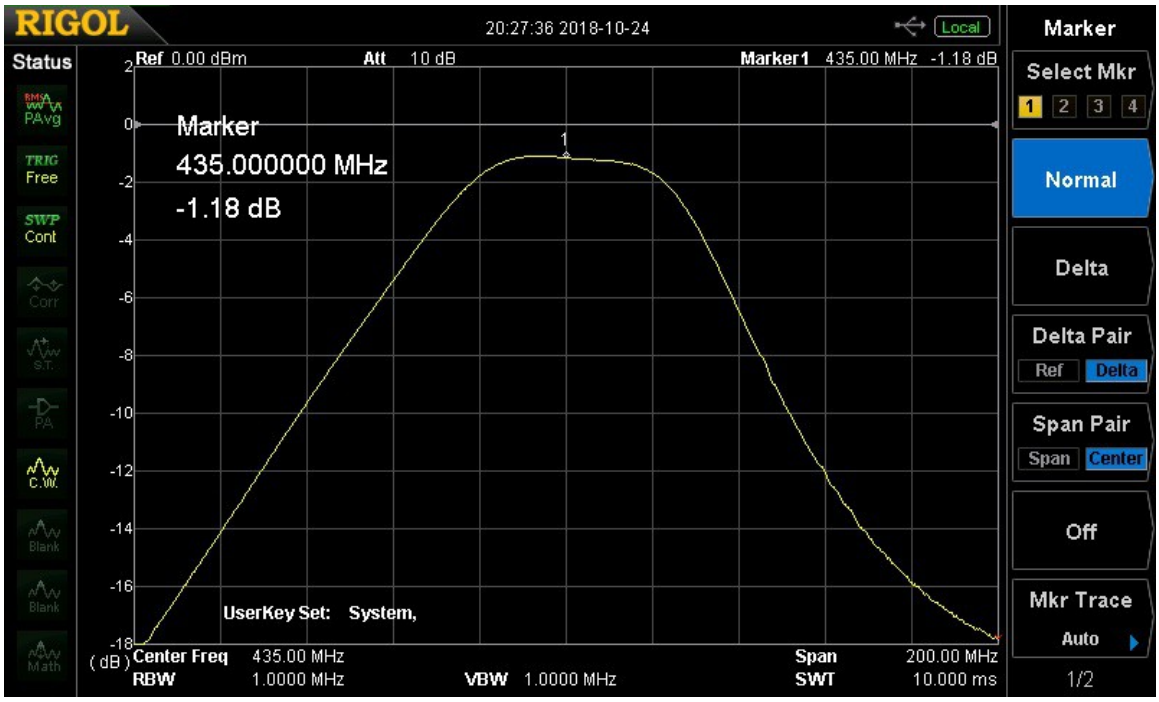

70cm BPF S11 Return Loss: 350 to 500 MHz, 1dB/div & 20MHz/div




interior view showing mounted pc board. note 2 turn loops, L1 thru L4.

I then actually built the combo HPF/LPF. I used one of my own model UWBA amplifier pc boards as an FR-4 base. It already had a layout for attaching SMA connectors and also a 50 Ω circuit trace from input to output. A few simple cuts with a sharp knife enabled me to have appropriate solder pads to attach the various L & C components. I used 1206 SMD capacitors for C1, C2 & C3. I used 0805 SMD capacitors for C4, C5 & C6. For the 18 nH inductors, I used a two turn loop of #26, bare wire. I found an on-line calculator for calculating the inductance. http://www.circuits.dk/calculator_single_layer_aircore.htm The calculator said to use 2 turns #26 with a diameter of 0.125" and coil length of 0.03". I added about 0.1" on each end as tabs to be soldered to the pads. I formed the circular loops by bending the wire around a 1/8" drill bit. I fine tuned the inductance by stretching or compressing the two coils.

The results were quite satisfactory. The mid-band S21 insertion loss was about -1.2dB. It was flat from 420 to 445MHz where I wanted it to then start rolling off. The -3dB bandwidth was 70 MHz, extending from 400 to 470 MHz, per the design. The S11 return loss was excellent across the whole band being better than -18dB. The out of band, insertion loss was about -50dB at 150 MHz and 750MHz. After 750 MHz, the IL started to rise reaching -35dB at the 23cm band. This rise was not predicted by LT-Spice.




S21, Insertion Loss: center freq = 435MHz, 200MHz span 2dB/div & 20MHz/div

**International ATV Networking** On the 8th of November Boulder ATV net we did some international networking. Jim, KH6HTV, checked into the net with both audio and video from his winter home on the island of Maui in the Hawaiian Islands. Jim first established communication with the net on the 2 meter voice intercom frequency of 146.70MHz, via the internet, using the Boulder Amateur Radio Club's (BARC) remote base station located at the clubhouse at the Boulder Municipal airport. This remote HF/VHF station is available for all BARC members and can be accessed via the internet. For more details on the BARC remote, contact Don, N0YE. Jim was also watching the ATV net's video via an internet stream provided by Don, N0YE, using VLC. Note: the ATV Net's normal stream via the BATC is not yet up and running. Larry, K0PYX, is gearing up to again put the net's video on the BATC server, but his hardware is not yet ready for "prime time".

When it was Jim's turn to put video on the ATV net, he turned on his TV transmitter in Hawaii. Hey, this is ham radio and in the spirit of things he really needed to radiate a true RF signal ! ! ! He transmitted a low power, 300mW, DVB-T signal on 423MHz from his home in Pukalani, Maui thru his Diamond X-50 antenna on the roof. OK, it really didn't go very far. He then received his own signal in his shack on a Chinese "combo" receiver with a 6" wire whip antenna. Great DX ! a distance of perhaps 10 yards ! ! ! Taking the composite video (plus audio) output from the combo receiver, it was then patched to a composite to USB dongle on his HP, windows 10, laptop computer running the program V-Mix. V-Mix then streamed Jim's A/V to England and the British Amateur Television Club's web site. ( https://batc.org.uk ) The BATC site, then re-broadcast Jim's stream for anyone to view. ( https://batc.org.uk/live/kh6htv ) Several of the Boulder ATV hams were able to see it immediately on their computers via the internet. Bill, AB0MY, took the HDMI monitor output from his PC computer and

patched it into his Hi-Des HV-320 DVB-T modulator and then re-transmitted Jim's A/V signal up to the Boulder ATV repeater on 23cm (1243MHz) where it was then re-broadcast all over the Denver metro area on 70cm, channel 57 (423MHz). Jim's video was brief, mainly a tour of his Maui ham shack, but it proved the feasibility of our international networking, half way around the world ! ! Hawaii (middle of the Pacific Ocean) --> England (eastern Atlantic Ocean) ---> Boulder (AB0MY) (center of North America) ---> Denver Metro Area (Boulder ATV repeater).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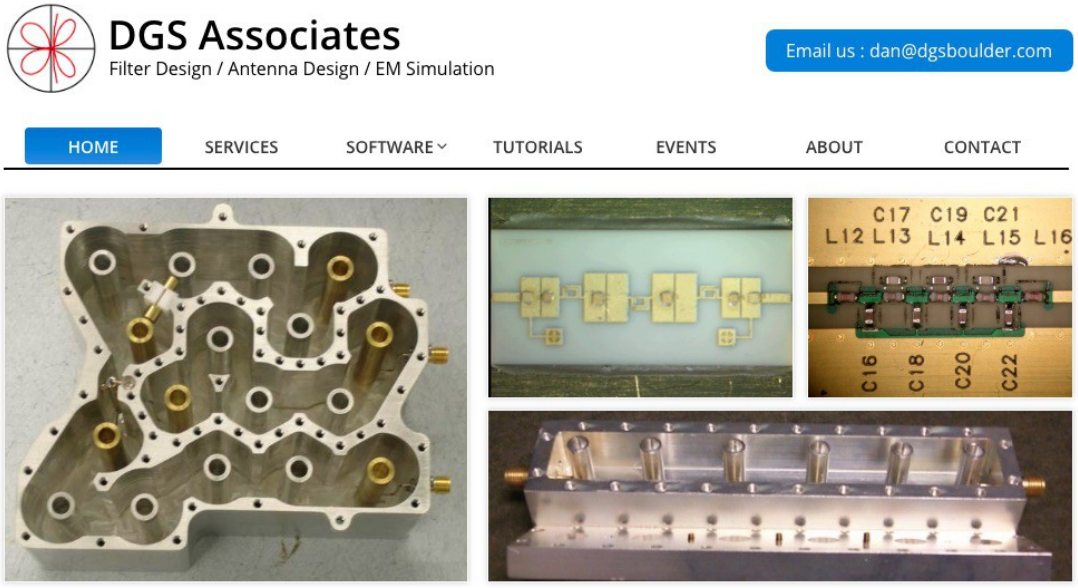
Dan received his BSEE degree from the University of Illinois and his MSEE degree from the University of Michigan. He started his career at Narda Microwave West, where he developed broadband amplifiers and a de-embedding system for S-parameter device characterization. At the Wiltron Company he designed YIG tuned oscillators for use in microwave sweepers. He also developed a broad-band load-pull system for optimization of output power. At Avantek Inc. he developed thin-film microwave filters, software for filter design, and a low-frequency, broad-band GaAs MMIC amplifier. In 1989, he joined Watkins-Johnson Company as a Staff Scientist. His work there included thin-film filter design for broadband surveillance receivers, high performance filters for wireless base stations, and the application of electromagnetic field solvers to microwave component design. Mr. Swanson joined AMP M/ACOM in 1997 where he was a Senior Principal Engineer. As a member of the Central R&D group, he applied electromagnetic field-solvers to the design of multilayer PC boards, RF and digital connectors, couplers and other microwave components. Mr. Swanson joined Bartley R.F. Systems in 1999. He designed high Q filters for wireless base stations and developed novel design methods based on EM simulation. Mr. Swanson returned to Tyco Electronics (M/A-COM) in 2003 as a Distinguished Fellow of Technology. As a member of the Strategic R&D group he supported filter and antenna design efforts and consulted on EM simulation issues in general.

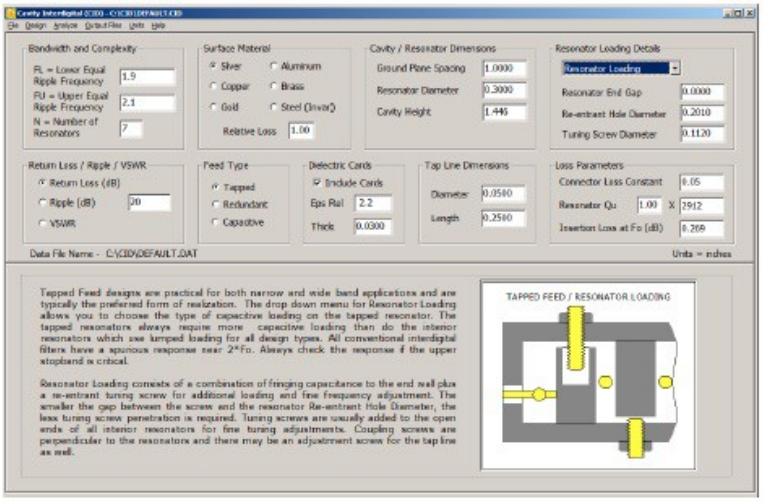
Mr. Swanson is a Fellow of the IEEE. He is past chairman of the MTT-8 Filters and Passive Components Technical Committee. He is on the editorial board for the *IEEE MTT-S Transactions, IEEE MTT-S Microwave and Wireless Components Letters,* and the *Int. Journal of Microwave and Millimeter-Wave Computer-Aided Engineering and Microwave Journal.* Mr. Swanson is the primary author of *Microwave Circuit Modeling Using Electromagnetic Field Simulation*, published by Artech House. He has published nu-

merous technical papers, given many workshop and short course presentations, and holds two patents.

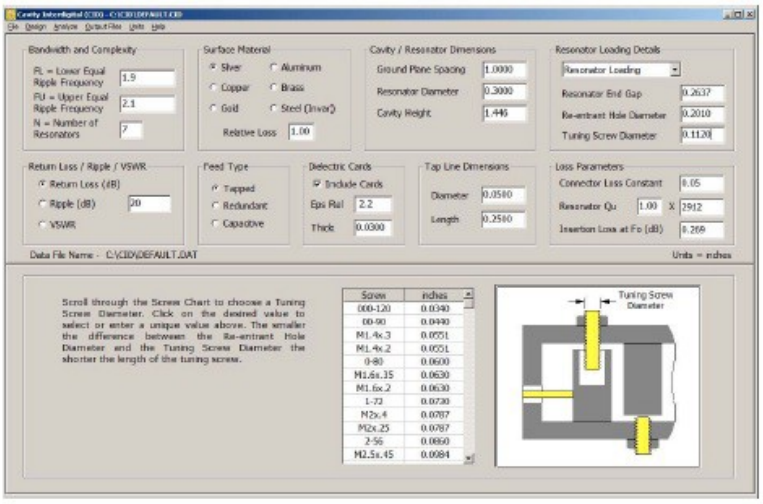
Dan now resides in Boulder, Colorado and has his own filter design company, DGS Associates. ( www.dgsboulder.com ) He is a licensed, advanced class, amateur radio operator with the call sign, WB9AIA. He is an active member of the Boulder, Colorado radio community.



# CAVITY INTERDIGITAL (CID)




The Cavity Interdigital (CID) program is used to design and realize cavity interdigital type filters with nearly exact equal ripple (Chebyshev) passband response using an equal diameter round rod conductor array. CID is menu driven with all required design parameters in a single menu. The program provides all dimensions required for fabrication and a complete analysis capability. Knowledge of network synthesis, equivalent circuits or circuit transformations is NOT required to use this program.




The program provides on screen help for all required inputs by means of a dialog window below the main menu. The program is also extensively error trapped to eliminate unrealistic or inappropriate parameter entries. The help screen for tuning screw diameter is shown above.

# CAVITY INTERDIGITAL (CID)

**Interdigital Circuit Model**

The program includes an exact synthesis for the commensurate line length combline circuit model, followed by numerical optimization to achieve a nearly exact Chebyshev passband response including the effects of lumped and / or non-commensurate elements.

**Input / Output Coupling**

Three different options for input / output coupling are available in CID. Tapping directly into the input and output resonators is probably the most commonly used method. CID uses an internal optimization routine to adjust the resonator couplings, resonator tunings and tap position to give a nearly exact equal ripple passband performance for arbitrary choice of tap line length and tap line diameter. Capacitive coupling with a resonant input rod and redundant coupling with a shorted input rod are also available.

**Design Capability**

The CID program is very versatile and can handle a wide range of design parameters and physical forms of realization. The program will design filters with up to 25 resonators for bandwidths of less than 1% to greater than 67% (octave). The accuracy of the program has been verified by measured performance of numerous designs and by EM simulation.

**Estimating Filter Order**

The user can specify the filter order or enter a table of required rejection levels at specific stopband frequencies. CID can then estimate the filter order needed to satisfy the specified rejection requirements.

**Analysis Capability**

CID contains analysis capability to compute insertion loss, return loss, group delay, deviation from linear phase and real and imaginary parts of the input and output admittance or impedance. The effects of incidental dissipation caused by finite Q elements are included by means of a true lossy analysis.

**Output Files**

The output data file created by CID contains all dimensions required for fabrication of the filter and the filter equivalent circuit. An S-parameter file is also automatically generated for use with other simulators. CID also creates a design file that captures all the input parameters to the program as well as any custom plotting parameters defined by the user.

**Key Features**

- The most accurate program available for interdigital filter design.
- Support for tapped, capacitive and redundant input/output coupling.
- N=2 to 25 and bandwidths of less than 1% to greater than 67%.
- Support for Imperial and metric units.
- Template files for analysis and optimization with NI AWR Microwave Office.
- Optional add on programs to build ANSYS HFSS or CST Microwave Studio models.
- Tested and supported on 32 and 64 bit versions of Windows XP and Windows 7 thru 10.