Collins Mechanical Filters for the FT-817

The W4RT Electronics Retrofit One Board Filter (OBF) Assembly

Greg Buchwald—K9QI agb002@email.sps.mot.com

This will be my third article for QQ and I just can't seem to get off the subject of the FT-817 transceiver from Yaesu. In April, I discussed my thoughts and findings concerning the performance of the -817, while in the July 01 issue I reviewed several products observed at Dayton this year including the OneTouch Tune Module from W4RT Electronics. I met Barry Johnson from W4RT Electronics at Dayton and had the pleasure to visit with him once again at the Huntsville Hamfest on August 18th. It was at the Huntsville Hamfest that he gave me a first look at a new product which W4RT is now introducing: A single board conversion package which houses two Collins Mechanical Filters.

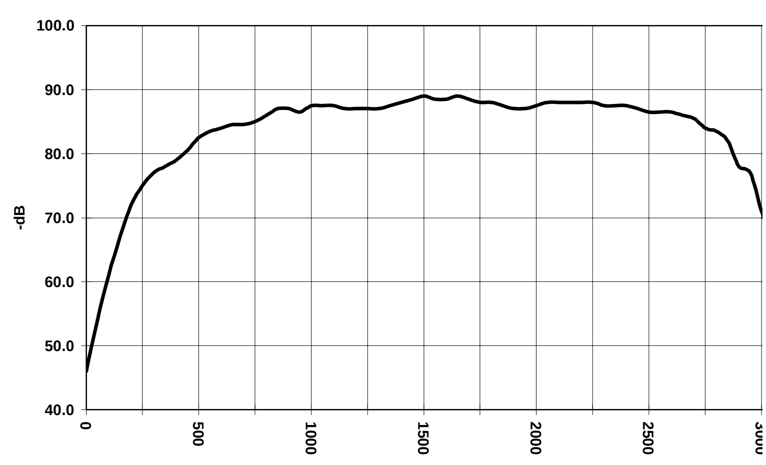
While the FT-817 is a great little rig, Yaesu has provided only one optional filter position on the RF circuit board as well as in the software sub-menu. For the CW-only or SSB-only operator, the choice is acceptable; simply install the filter required for your individual application. But, for those of us that like to run CW as well as SSB, PSK-31, and other modes, the decision as to which filter to buy has been a difficult one. I opted for the 500 Hz. CW filter since that is a requirement, not an option, in my mind, if you want to work the weak ones and operate near the sometimes crowded QRP spectrum on 40 and 20. On the other hand, there have been numerous reports on some of the reflectors discussing the advantages of installing the Collins Mechanical Filter for SSB use. The comments have ranged from better selectivity, to better sounding transmit audio, and, finally, more apparent punch / talk power. To see if there was any merit to this, I borrowed a second radio, from a friend, which contained the SSB Collins Mechanical Filter. Indeed, the improved receive selectivity was immediately apparent. In addition, I had recordings made of both radios at a location a few miles from my QTH - one radio containing the stock ceramic filter and the second utilizing the optional Collins SSB filter. I was amazed at the difference in the audio quality. Quantitative measurements were required to find out exactly what was going on.

Shortly after the recordings were made, I met up with Barry at the aforementioned hamfest in Huntsville. We had a chance to discuss the results that I had observed and he offered to show me his results along with a personal tour of a converted radio. What Barry had accomplished was to design a board, which utilizes two Collins filters, which are similar in performance to the optional filters offered by Yaesu. In order to utilize both filters without significantly altering the gain line-up of the transceiver or re-writing software to operate the rig, the board Barry manufactures replaces the stock 2.7kHz ceramic IF filter, a MuRata CFJ455K device, with the Collins 2.3kHz mechanical filter. The board also contains the 500 Hz. CW Collins mechanical filter. The key to accomplishing this effectively is to properly terminate the filters and be conscious of the layout of the retrofit board. This provides minimum loss through the filters, maintains the system gain line-up designed by Yaesu, and insures minimum ripple throughout the passband as well as the highest possible stopband performance. After our discussion at the show, I decided to send Barry my radio for conversion. He agreed to put a first pass board into my radio, along with randomly selected filters, which he had in stock. Since the conversion required the removal of components, including some surface mount parts, W4RT Electronics plans to sell the conversion only with installation. Just to make life more miserable for Barry, I told him that I had spoken with the editor of QQ and secured a spot in this issue - but he had to turn the radio around in 48 hours. Before conversion, measurements were made of the stock IF filter response in the SSB mode on 20 meters. After the data was collected, I Fed Ex'ed the radio to Barry. Two days later, I had the radio back with the filters and modification board installed. It was time to make some comparative measurements.

There are really only two simple ways to measure the IF response of the radio: 1) Probe the IF at 455kHz and sweep the radio, or, 2) cheat a bit and sweep the radio at the RF input with a single carrier and measure the audio response. Since the latter reflects the overall response of the radio, it was the method that I chose to utilize. Besides, it is much easier than getting inside the radio and using a FET probe to 'look' at the IF. Plus, the capacitance of a FET probe could affect the measurements if method one were utilized. The underlying requirement to insure the proper collection of data when using method 2 is that the AGC must be defeated. On the -817, this is an easy procedure utilizing the AGC sub-menu. The results were quite interesting.

In Figure 1 we have the swept response of my radio prior to conversion. This reflects the response of the MuRata ceramic sideband filter. In all fairness, I was actually impressed that a small, inexpensive filter of this type could produce this good of a response curve. The -6dB points are about 500 Hz - 2800 Hz, for an overall response of about 2300 Hz. Once again, all measurements were taken on 20 meters. It is interesting to note that the response has a quasi-gausian look to it. While the skirts are fairly steep, there is a definite peak at 1500Hz with roll-off on either side. At 1200 Hz, there is about 2dB of passband ripple. We see about 1.5dB of ripple on the upper side of 1.5kHz, near 1.9kHz. With reference to the peak at 1.5kHz, the -20dB point does not occur until about 125Hz on the low

MuRata SSB Filter (Standard) In Radio



side and nearly 3100 Hz on the high side representing a total -20dB bandwidth of 2975 Hz. In receive mode, there would be considerable energy from a strong adjacent signal, which would affect the ability to hear a weak on-channel station. Furthermore, the quasi-gausian shape of the filter will impact the quality of the received audio. On the transmit side, considerable low frequency energy will pass to the final amplifier, potentially robbing so-called talk-power which is so desperately needed for QRP sideband operation. Finally, not shown in this graph is the non-linear group delay of the filter. This will be discussed later. To confirm the response of the stock filter, Barry provided me with his graph of a second stock filter. This is shown in **Figure 2**. The similarity of the two filters is obvious.

Next, the modified radio was tested in both the SSB and CW positions. The Collins filters are mechanical resonator type filters with 10 poles of selectivity for the SSB variety and 7 poles for the CW version. In **Figure 3**, the response of the SSB filter in my converted radio is plotted. The -6dB bandwidth extends from 550 - 2900 Hz (2350 Hz.) and the -20dB bandwidth extends from 450 - 3100 Hz (2650Hz). While it could be argued that the-6dB bandwidth is nearly identical (actually the Collins filter is 50Hz wider in my sample), the 20dB bandwidth presents an entirely different picture. The Collins filters are 325Hz narrower at this point - a much better shape factor providing better attenuation of unwanted signals. The other obvious difference is the flat response of the filter. The SSB filter has less than 1dB of ripple throughout the passband. On the transmit side, this insures that higher frequency components - those generated by consonants - will be articulated at the distant receiving station. For those hams operating QRP PSK-31, it means a more uniform relative signal strength (and therefore flatter MDS) as you tune across the waterfall display trying to pick the station which you wish to converse with.

At this point, it is important to also note that the ceramic filters have a greater non-linear group delay characteristic as compared to the Collins filters. The group delay of the sideband filter is very flat throughout the center 2/3 of the passband. As you approach the stopband, both filters have wildly fluctuating non-linear group delay response, which is expected of any elliptical filter response (any filters with zeros in the stopband, which provide the step skirts required). While some will argue that my next statement is not true, I am of the opinion that it is the linearity of the phase response of the Collins filters, when used in the transmit path, which produces a received signal that seems better articulated. It is not simply a case of a few more higher frequencies passing through the transmit chain; it is the time alignment of the higher frequencies portions of the voiced energy with the lower frequency components which adds to the improved quality of the transmit audio when the mechanical filter is utilized.

Figure 4 is a plot of a second SSB filter as measured by Barry. This gives a good repre-

Figure-2

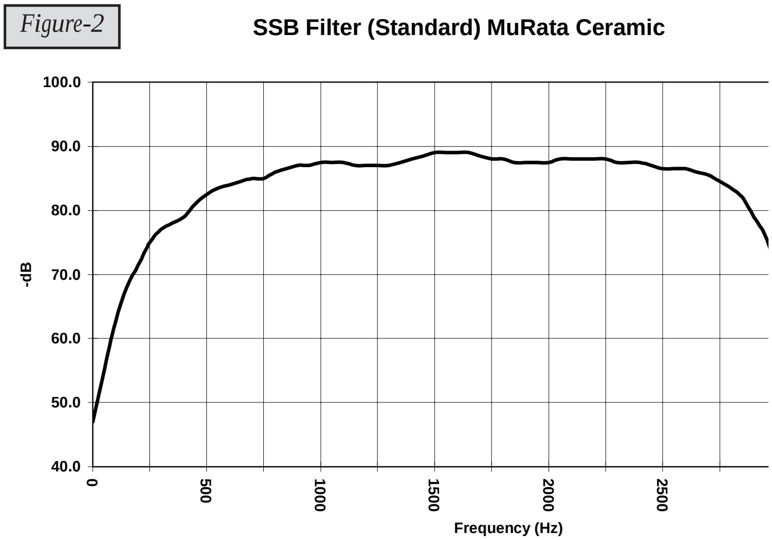


Figure-3

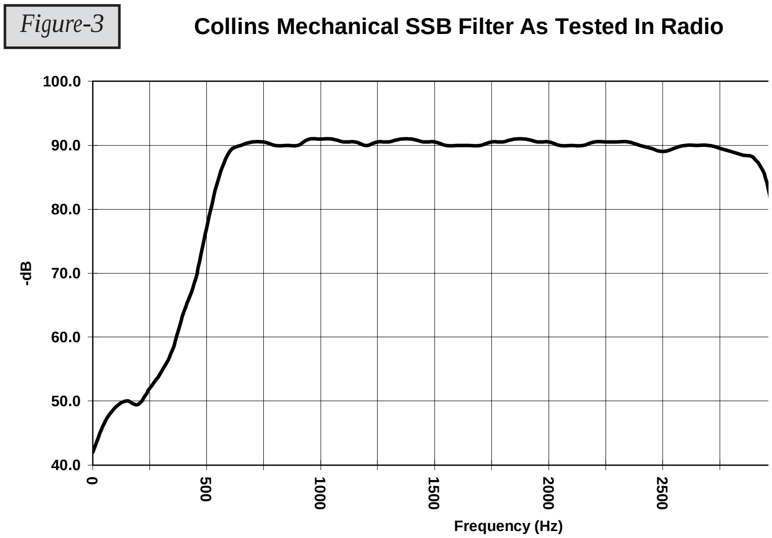
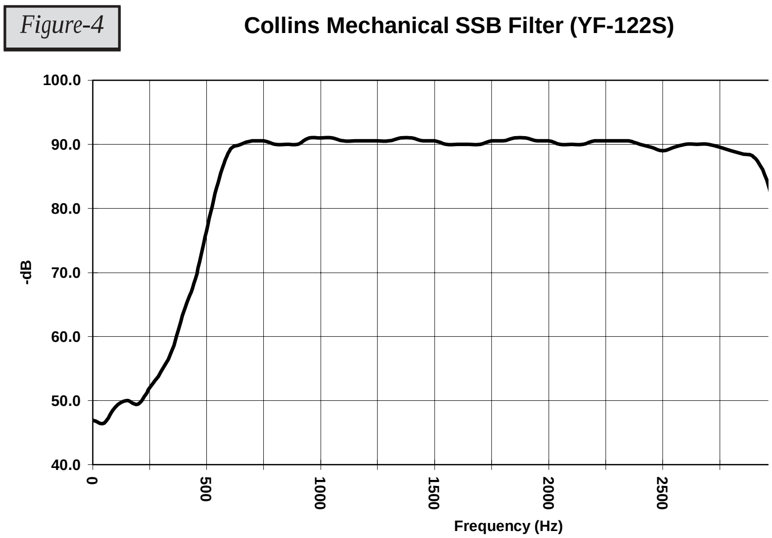


Figure-4



sentation as to the consistency of the filters Barry has selected to purchase from Collins.

Finally, Figure 5 indicates the response of the CW mechanical filter. Once again, the filter is a seven-pole design. The -6dB response extends from about 400 - 1000 Hz (about 600 Hz. Bandwidth) and the -20dB response extends from 350 - 1100 Hz. (about 750 Hz bandwidth). The improvement of CW operation over either the stock ceramic filter or the SSB mechanical filter is dramatic, as one would expect. There is higher passband ripple, about 2dB, but this is also expected due to the close placement of the resonator center frequencies and zeros. Once again, the filter has a rather good non-linear group delay response, making for a good CW note without ringing, but those fortunate hams that have owned radios with Collins mechanical filters have known about that for years. Figure 6 is a graph of the CW filter response as taken by Barry (this is a separate filter - once again indicating the uniformity of the response curves).

I also wanted to quantify, in some way, the increase in talk power that is obtained by the installation of the filter. When looking at Figure 1 as compared to Figure 3, the steeper skirts of the mechanical filter are readily apparent. What isn't quite so obvious is the energy contained in the passband as opposed to the stopband. More important is the energy contained in the transitional bandwidth of the filter - that region of the response curve where the filter is beginning to roll off and the point at which -20dB is attained. On the low frequency side, large amounts of energy exist in these lower frequencies. Many readers might be surprised to learn that the 1/2 power bandwidth of voiced energy occurs at about 350Hz! That is to say that about 1/2 of the energy occurs at frequencies below that point and the other half of the power exists above that point. (It is for this reason that narrow band FM systems can utilize a 750uSec. pre-emphasis specification - effectively raising the energy above 210 Hz at a rate of 6dB / octave with a reciprocal reduction - de-emphasis - in the receiver to get a dramatic reduction of noise). But the

Figure-5

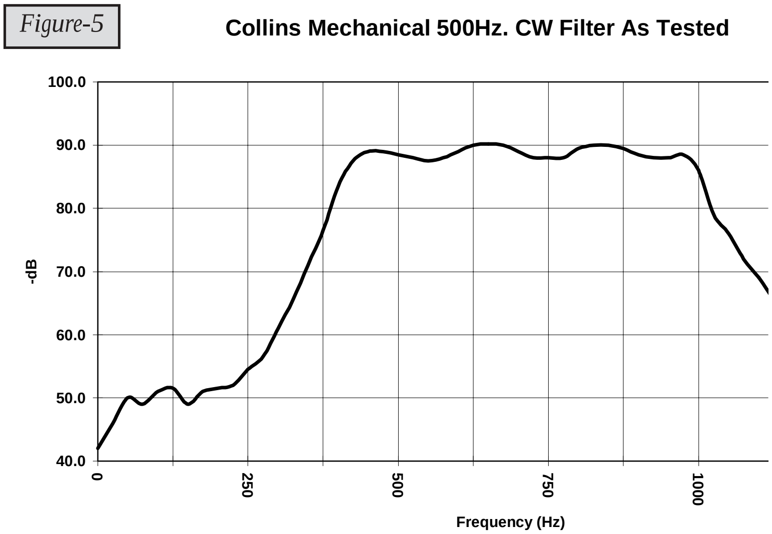
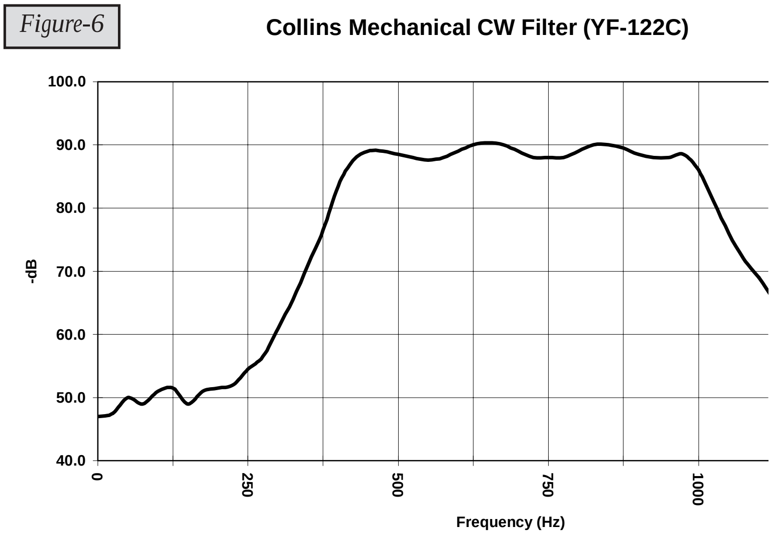


Figure-6



Above—The Collins CW Filter

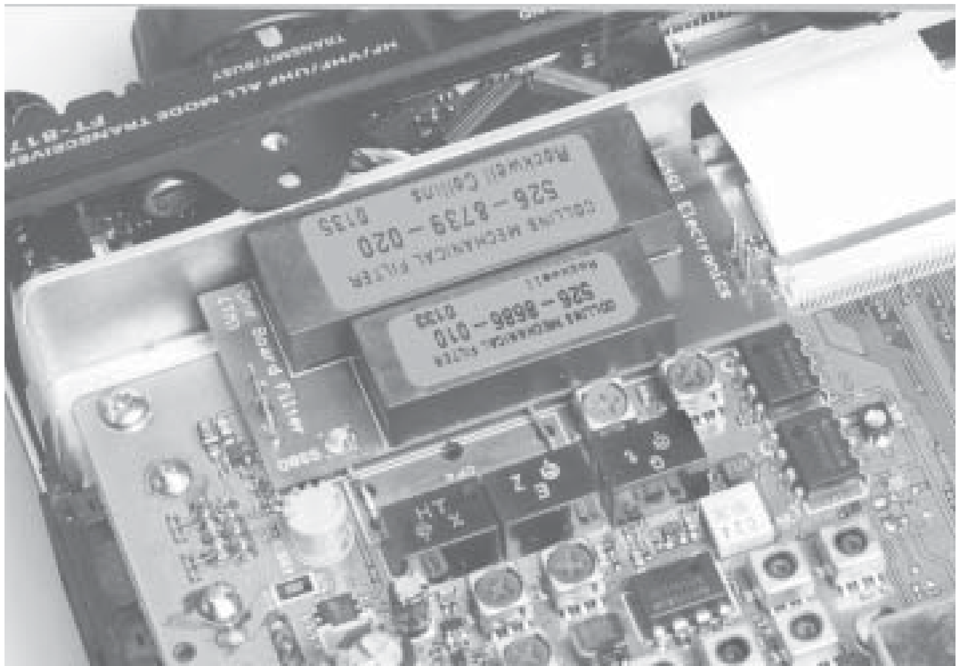
Below–The W4RT One Plug Filter

energy below a point starting at about 300 Hz does little for communications quality speech. By removing this energy, large amounts of reserve peak envelope power can be diverted to voiced frequencies, which do improve the overall ability to receive the transmission. In my conversations with Barry, he spoke of a test which he tried utilizing a distant receiver and an RMS-reading audio voltmeter to try to ascertain the improvement in average talk power. His experiment revealed a 2dB increase in received audio energy for the same overall signal strength. Remember that the IF filter in the distant receiver also plays a role in these results. I duplicated the experiment, but performed it in a slightly different way.

My converted -817 was connected to a dummy load / attenuator. I utilized 80dB of attenuation and the resulting .05uW (1.58mV / 50 ohms) was considered a strong signal and fed into a FT-1000D. The widest possible IF filter position was chosen for the passband on the FT-1000D as that would minimize ringing caused by non-linear group delay in the IF filter. The resultant received audio was measured on a Potomac Instruments Quantaural Analyzer. This device is usually used to measure the peak to average ratio, thus the apparent loudness of, commercial entertainment broadcast stations. In this case, I utilized the peak-to-average measurement capability of the device to determine the average increase in talk power. My findings indicated a 1.6 - 1.8dB increase in talk power when the mechanical filter was used in place of the ceramic sideband filter. This was, of course, based on my particular voice as I read in a monotone fashion from a copy of QQ. I then spoke to Barry who suggested that I modify the carrier offset (an extended menu item on the -817). Since my voice tends to contain more lower-frequency energy, this adjustment might center the passband of the filter to match the specific characteristics of my voice. I was skeptical at first, but it did make sense and I tried it. I eventually found a setting - about 100 Hz lower than the original setting - in which I obtained a 2.1dB increase over the stock filter results. This was good stuff! By adding the W4RT filter board, I not only got the benefit of the filter response for SSB work, but I also gained the equivalent of cranking up my power by 2dB without changing my true PEP one bit. That's like running 8 watts rather than the 5 the rig actually puts out. Sure, that doesn't seem like much, but in some situations, every bit helps. Plus, I could only estimate that the increased clarity of the signal, due to the sharper skirts and the more uniform phase delay response, added the equivalent of another 3dB or so energy. To me, the rig was producing much improved results over a stock, bare bones unit. Thanks to Barry for making this suggestion.

Here's one last note concerning the operation of the converted receiver. When the unit is sent to W4RT electronics for modification, the filters will be installed and menu #38 (accessed by holding the function key down until the second beep is heard followed by rotation of the selector knob until #38 is displayed) will be programmed for the CW optional filter. Once that is done, the normal menu, accessed by a quick push (one beep) of the function button will take you into the everyday use panel. Rotating the selector knob will bring up "nar" on the right-most position and a simple push of the button below the "nar" indication will switch the radio into the CW filter mode. The radio will remember which filter position you want to operate in for each mode on each band. Operation is actually quite simple - no different than having the Yaesu optional CW filter installed.

Are there any down sides to the conversion? The answer is a resounding NO! While it could be argued that utilizing the stock ceramic filter in series with the Collins mechanical SSB filter might improve the ultimate rejection ratio of the receiver, the ripple of the ceramic filter is still present and will, at certain frequencies, be additive to the added mechanical filter. I think the properly terminated replacement method Barry has chosen is the correct solution. Furthermore, I saw no change in the sensitivity of the receiver. In fact, the MDS on CW remained at -136dBm - exactly where I had measured it with the stock ceramic filter plus the optional Collins mechanical filter from Yaesu. There is no need to be concerned over any loss of performance; my findings have indicated that there is a considerable increase in performance over the stock radio.



The Installed W4RT One Plug Filter Assembly

The final question is "What will this improvement cost me?" The answer is, at the time of writing, $275. This includes installation of the board with both filters. While this price may seem high at first, the Collins filters are pricey items to begin with. If you buy the individual filters from Yaesu, they will set you back about $160 / each. For less than 1/2 the cost of buying the two filters, you get the flexibility of having both filters, the board and termination modifications required, and the labor to install the unit. Once again, since the board is a bit tricky to install, W4RT only offers the unit as an installed item - you must send your radio to them. But, in exchange, you know that the conversion has been done carefully and the filter operation is tested prior to the radio being shipped back to you. While most of us do not need fast turn-around like I requested, I was very impressed, once again, with the professional nature in which Barry handled my order and got my modified radio back to me. In case anyone is wondering, I also paid the full price for the modification and insisted that I be allowed to write my thoughts and reflections about the conversion. As it turned out, my only concern throughout the process was whether I would get my radio back in time to perform all the tests I hoped to perform to write this article. As mentioned above, the radio was returned to me quickly and it was packed very well. The old ceramic filter was found in a sealed bag in the bottom of the box along with a few rubber feet to mount on my radio to keep it from slipping on the desktop - a little bonus! Bottom line, if I didn't like the product I would have printed that as well. But, I can't praise it high enough. This is exactly what the rig needed!

For those that do not want to add the entire conversion, W4RT Electronics is offering individual filters, which do plug into the optional filter socket in the radio. The same 10 pole SSB and 7 pole CW filters are available at considerable saving over the cost of the factory units.

For more information on the filter upgrades and other accessories available from W4RT Electronics, check their website at www.w4rt.com. ●●

Tips Learned From Portable Ops:

Always put a wrap of electrical tape (or other insulation) over your battery terminals when packing them. Same idea as not carrying your HT batteries in a pocket where they can come in contact with car keys. (Been there, got burnt.)

Solar panels can still work on overcast days, but much lower power. I worked with a 12 watt panel once using one watt output just barely keeping up (had to QRT at sundown).

You are often the highest thing around, and you have this tall signal attractor at your picnic table, Lightning likes that sort of thing! QRT and tear down early if any storm approaches.

Insects biting at your ankles hinders your ability to send/receive CW. And they seem to like to wait till you're in QSO to come out. Roy Parker—AA0B
http://web.missouri.edu/~ccrip ●●