Methods of Tuning Cavity Resonators According to Application

By:
William F. Lieske, Sr.
Founder, EMR Corporation

Forward

Cavity resonators have been used in land mobile, radio broadcast and related applications for more than fifty years. Various types and combinations of these devices are found in modern systems as elements of band pass filters, pass notch filters, antenna duplexers, receiving preselectors, transmitting filters, transmitter combiners and similar devices. Cavity resonators are also employed as the tuned elements of input and output circuits of high power vacuum tube high power amplifier design.

It is hoped that this bulletin will lead to a better understanding of the various types of cavity resonators found in land mobile and radio broadcasting systems. The electrical characteristics and proper methods of adjusting them according to intended usage will also be discussed.

This information should be valuable to the engineer or technician involved in land mobile and radio broadcast radio systems and translator application work.

What is a Cavity Resonator?

The nature of a typical 1/4 wavelength antenna can be used to describe how cavities function. Communications engineers and technicians are familiar with the traditional 1/4 wavelength transmitting antenna. It consists of a radiating element that is electrically equivalent to a 1/4 wavelength at the operating frequency of the transmitter. A formula for the length of such an antenna is:

$$\text{Length (ft.)} = \frac{234}{\text{Frequency in MHz.}}$$

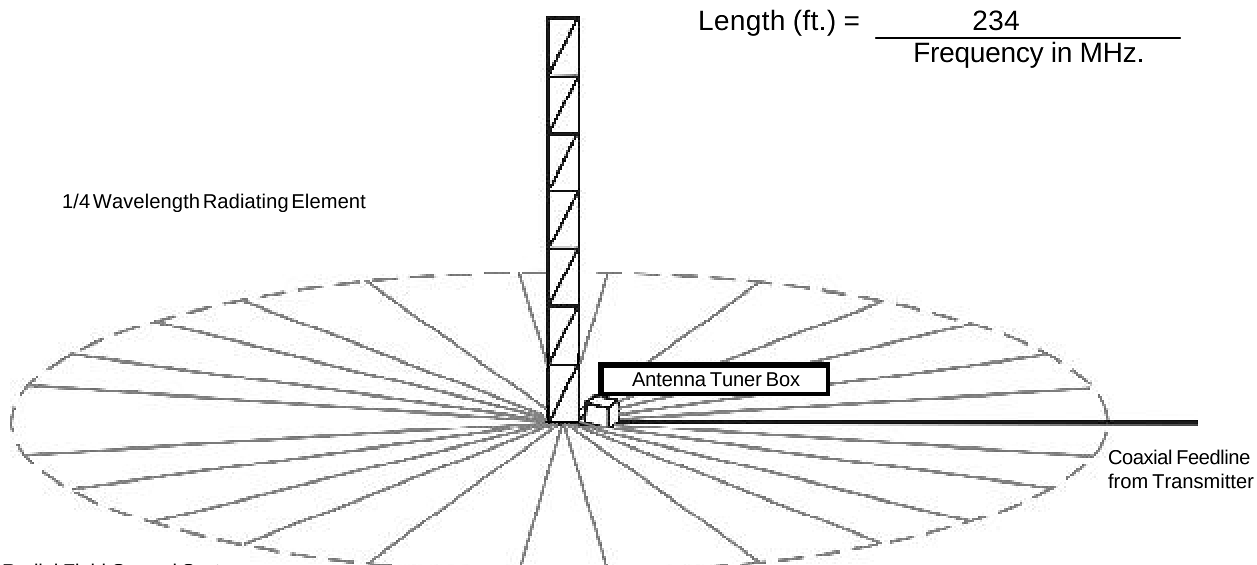


Figure 1

Methods of Tuning Cavity Resonators - According to Application

An AM broadcasting antenna for 1240 KHz. would come out to about 189 ft. using this formula. In practice, the length would be somewhat shorter due to the effective area of the antenna tower, added capacitive loading of insulated guy wires, etc. At a frequency of 155 MHz., a 1/4 wave two-way vehicular communications antenna is about 18” long.

For a 1/4 wavelength antenna to function, it must have a *ground plane* to work against. As depicted in Figure 1 a typical AM broadcast 1/4 wavelength antenna is provided with a ground plane of conductors buried just beneath the Earth’s surface surrounding the base of the vertical element. Each radial must be at least 1/4 wavelength. The greater the number of radials the better the ground plane.

The nature of the soil and other factors will determine the drive impedance (radiation resistance) of the antenna. With 120 or more radials the base impedance of the 1/4 wavelength radiator can be as low as 15 or 16 ohms, particularly where the earth is generally moist or where the soil contains conductive minerals. Where the soil is low in mineral content and relatively dry the base impedance can be as high as 50 ohms. Power from the transmitter is fed to the antenna via a transmission line. A “tuning box” is usually required to provide a match between the transmission line and the feed point at the base of the antenna.

The 1/4 wavelength antenna is used here as a means to describe the effect in which a resonant 1/4 wavelength element will convert radio frequency power into electromagnetic energy that can be propagated through space. If we were to use an infinite number of radials such that the ground plane becomes a solid metal disc and at some distance “x” from the base of the antenna the disc is bent up to form a cylinder we would find that the antenna is still resonant. However, the resonant frequency would be slightly lower due to the distributed capacitance between the radiating element and the cylinder walls.

If the cylinder walls are extended to 1/10 wavelength or so past the free end of the radiator and a cover is placed over the end, a functional cavity resonator is the result. As shown in Figure 2, we can add loops to induce R.F. power into and out of the cavity resonator and make the element such that it is adjustable in length. In this manner we can tune the device to resonance over a usable range of frequencies.

We can now adjust the size of the coupling loops to match our system impedance. If we make the loops rotatable we can adjust the degree of coupling into and out of the cavity. The cavity becomes a frequency selective filter, passing the resonant frequency and providing rejection of other frequencies. If the cavity diameter is enlarged, selectivity is improved compared with a given coupling loss through the cavity.

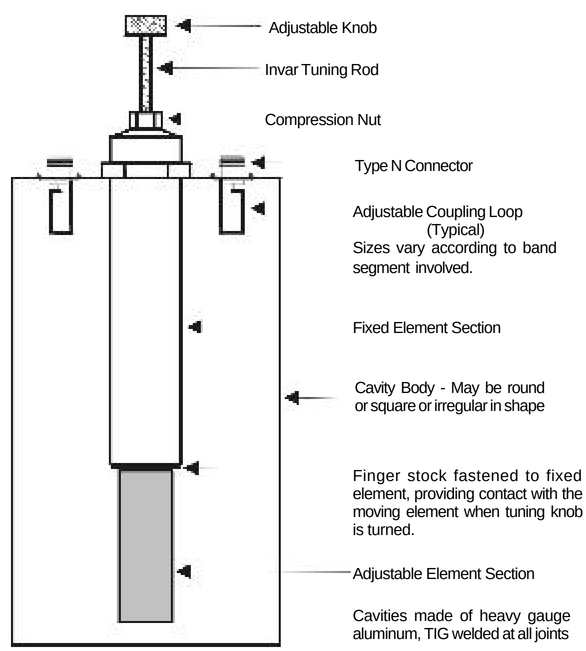


Figure 2: Cavity Resonator Cut-Away View

Methods of Tuning Cavity Resonators - According to Application

A cavity resonator does not have to conform to any specific shape to be usable. It can be round, square, rectangular, pie shaped, have many sides, etc. The volume of the cavity essentially determines its performance. Round forms are found to be popular since the cylindrical shape is easy to find in terms of materials such as pipe or rolled sheet metal tubular shapes.

"Q" is defined as the ratio between reactance and resistance in a tuned radio frequency circuit. The lower the *radio frequency* resistance of the materials that the cavity elements are made of, the better the "Q" for a given set of dimensions. For this reason the outer cavity body is constructed of relatively low R.F. resistance material such as copper, brass or aluminum. The resonator elements are usually constructed from brass or copper tubing and silver plated to yield low surface resistance and reduce skin effect losses at radio frequencies; since R.F. energy tends to travel on the outer surface or skin of metals. Where the cost is justified, gold plating is employed.

Characteristics of Cavity Resonators

Cavity resonators have many interesting operating characteristics. Here are most of the points of interest that we should remember:

1) Cavity resonance is adjusted by changing the position of the moving part of the resonator element. Lengthening the element moves the frequency lower; shortening it raises the frequency. Most adjustable length resonator elements use some form of spring loaded contacts (often called *finger stock*) to maintain suitable contact between the fixed and movable element sections.

2) Frequency adjustment is usually accomplished by turning a threaded rod to move the adjustable element section in or out. The rod used in most cases is made from a material called INVAR, named for its essentially invariable nature, having an almost zero coefficient of thermal expansion. The point of attachment of the *invar* rod is usually at the top of a riser or dome that protrudes out of the top of the body cylinder and made to a length suitable to provide temperature compensation of the device using the *invar* as a reference.

3) The dimensions and orientation of the coupling loops will determine the effective impedance of the cavity input and output, as well as the degree of coupling.

4) Cavity dimensions are determined by the frequency of operation, desired operating "Q" and operation TEM (Transverse Electro-Magnetic) resonance mode. The fundamental (lowest) frequency at which a given cavity will operate represents its TEM1 mode. This occurs when the resonant element is an electrical 1/4 wavelength. The cavity will also show resonance at 3rd (TEM3), 5th (TEM5), 7th (TEM7) and higher *odd order harmonics* of the fundamental frequency. Greater insight into Transverse Electromagnetic Mode theory can be found in texts on microwave theory as this applies to wave guides and self resonant bodies.

5) Cavities may be of many different geometrical shapes. Round cavities are the most popular since, as we said before, various round tubing forms are commonplace. EMR Corporation employs square or rectangular forms in the majority of our designs since their smaller volumes package into physically smaller multi-cavity filters and transmitter combiner, yielding better performance than equivalent round shapes that would occupy the same space. The *effective* volume of a cavity will in great part determine its "Q" and performance.

6) Commonly available metals having low electrical loss characteristics are used for cavity bodies. Due to cost, weight, machinability and assembly characteristics, aluminum is the most used material, with copper and brass finding popular application. Resonator elements and coupling loops are usually made from copper and/or brass and silver plated. The contact finger stock is usually made from mildly tempered beryllium copper or phosphor bronze.

7) Every cavity body will resonate naturally at a frequency determined by dimensions. Accordingly, there are certain cavity body dimensions that must be avoided, according to intended operating frequency band. It is possible to successfully tune TEM1 and TEM3 cavities either above or below the natural resonant frequency of the cavity body. It is often necessary to modify a cavity body dimensions to secure good performance in a particular band.

8) In the design of a cavity the maximum power to be handled, operating duty cycles and similar considerations will determine materials and construction methods. The purity of the metals used must be known, since the thermionics heating effects of radio frequency power conduction can pull corrosive impurities out of the metals. Metal joining must be accomplished by welding, brazing, silver soldering and high temperature tin-silver soldering, as applicable. Lead solder must be avoided.

Cavity Resonator Types

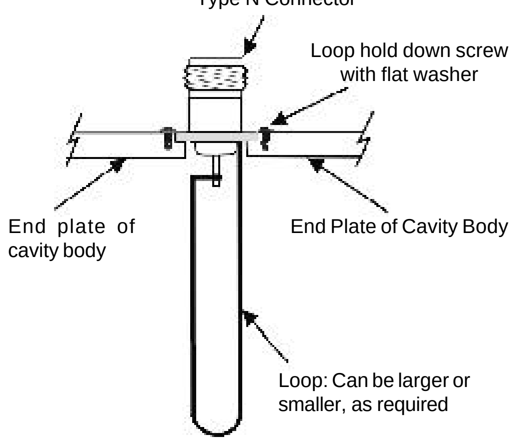
There are two basic types of cavity resonators: Band Pass and Pass Reject. The band pass type has two coupling loops, one to couple R.F. power into the cavity and another to couple the power out of the cavity. The coupling loops (see Figure 3) can have a fixed dimension and placement or can be arranged such that they can be rotated with respect to the TEM field to adjust the degree of coupling. Coupling loops are most often placed at the low impedance end of the cavity in which the element is placed. The choice of location of the loop is determined by the intended usage of the cavity.

The pass notch cavity employs only one coupling loop (see Figure 3). It is used to couple R.F. power into the cavity such that the TEM field is established. A relatively broad selectivity characteristic results when compared with a band pass cavity. There are two practical ways to develop a reject notch, the first of which involves using a single band pass type of loop. In this method, a “Tee” connector is placed in a length of coaxial transmission line and a length of jumper cable with suitable connectors is arranged from the tap-off of the tee to the loop. If the electrical length of the jumper is less than 1/4 wavelength a notch will appear above the frequency at which the cavity is tuned. If less than 1/2 wavelength the notch will be below the cavity’s tuned frequency.

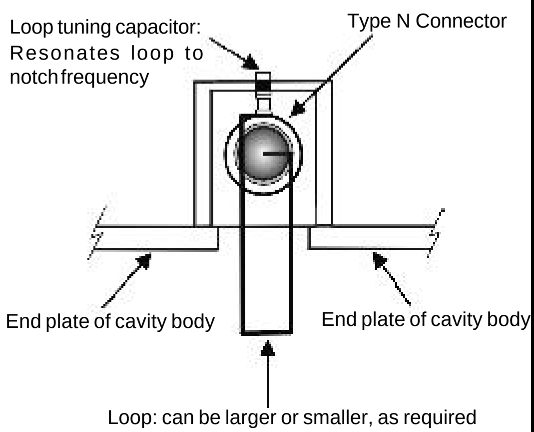
Rotating the loop to vary coupling factor and/or changing the jumper cable length will adjust the notch depth and notch placement compared to the cavity’s tuned frequency. The second method of developing a reject notch, and the most prevalent, involves resonating the loop itself by a series capacitor to produce the pass notch effect. A “tee” is fastened directly onto or integrated with the loop as a special assembly. If the loop assembly is made rotatable, typical notch depths from 10 to 45 dB may be secured with most TEM1 mode cavities. The range of notch characteristics will depend on the relationship between the pass and notch frequencies for a given cavity size and operating band.

Special cavity types are used for such applications as low power antenna duplexers, broad banded multi-element band pass filters and similar applications. Many of these employ capacitively tuned hollow copper or helical resonator elements to secure necessary performance with smaller size and less weight when compared to conventional TEM1 to TEM3 resonators. Most modern receivers employ small helical resonators or ceramic loaded resonators in preselector applications. Often, these resonators are *varactor tuned* using synthesizer generated control voltage to tune the filter to select operating frequency ranges.

Figure 3



Typical High Band Pass Loop Assembly



Typical 450 MHz. Pass Reject Loop Assembly

During the past several years continuing development has been carried on to find better materials to use in ceramic loaded elements or self resonator ceramic amalgamates. The most pressing problem to be solved in the use of these materials is management of thermal stability. Practical transmitting cavities can now be made to operate at 750 MHz. and above, and at power levels of 50-100 watts. We may expect to see continuing developments in the field of ceramics in resonators as improved ceramic compounds are developed. Our main interest in this bulletin is to cover the behavior of air dielectric cavity types and their applications.

Practical Band Pass Cavity Applications

The following information will introduce the reader to accepted methods of adjusting band pass cavity devices. Before going into tuning methods, however, we should consider the various uses for band pass cavities in somewhat more detail:

1) Band pass cavities as receiving preselectors. The purpose is to pass a range of desired received frequencies and to reject signals that are of no interest. This will reduce the receiver's exposure to unwanted high level signals that might otherwise cause desensitization through overload of the R.F. amplifier stage of the receiver. For spot frequency receiver front-end protection, one to three cascaded band pass cavities may be used to define a very narrow "window" of spectrum.

2) Bandpass cavities as transmitting filters. Wide band noise, spurious and harmonic energy can be radiated by transmitters. Multiple cavity filters will reduce the radiation of such interference source to tolerable system levels.

3) Band pass cavities used as elements of antenna duplexers. Two or three band pass cavities in each branch of a duplexer can provide a receiver with complete protection against carrier and noise interference from its associated transmitter and all other nearby transmitter. Also, where two or more combined repeaters are to share a common antenna, the band pass duplexer provides sufficient pass and skirt reject characteristics to make this operation possible.

An added benefit derived from using band pass cavities is the fact that the loops provide a path to ground for out of band high power signals and lightning sourced energy. This provides important protection to sensitive amplifier components.

Test Equipment Set-Up Required for Correct Cavity Tuning

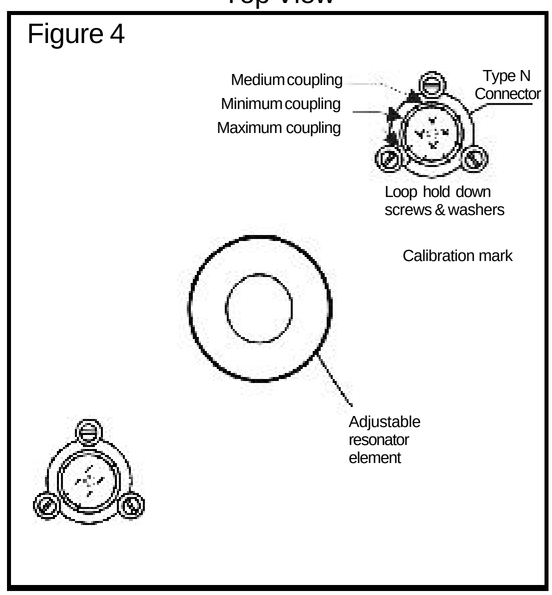
Before covering methods of tuning band pass and pass reject cavities, we will first look at the arrangement of element tuning and adjustment of the coupling loops. A top view of a typical 7" square EMR Corporation "Square Q" band pass cavity is shown (see Figure 4). The resonator elements is in the center of the drawing and the adjustment rod has a knurled knob. The rod is threaded and has a shaft locking nut as a part of the element "riser".

Each of the loops include a plated brass *loop plate* disc secured by three retainer screws. A Type N connector is placed in the center of the loop plate. A calibration mark appears on the loop plate as a convenience in orienting the loop position during the tuning sequence.

Note that some manufacturers place calibration stickers alongside the rotatable loops showing various coupling levels in dB. Such stickers are just guides to get you close to the desired adjustment. Precise loop adjustment is almost impossible using the calibrations alone. The procedures that we will cover must be followed carefully to result in correct loop adjustment.

The most desirable test instrument to use for this work is a *dynamic wave analyzer*. Such an instrument provides a calibrated swept source signal to a precise 50 ohm R.F. bridge output connector. To achieve accurate measurements the device under test (DUT), in this instance a band pass cavity resonator, must be fed by the R.F. bridge. If the bridge is not suitable for direct attachment to the cavity input loop use a length of coaxial cable that has been cut to represent a 1/2 wavelength at or near the frequency in question. Note that if the cable is of just some random length it may act as a *linear transformer,* magnifying

Cavity Body
Top View



Typical Square Format
Band Pass Cavity Resonator

Coupling loop adjustment determine throughput loss. When loops are in-line with the resonator, coupling is greatest. At 90 degrees from this setting the coupling is a minimum. For best selectivity at a given insertion loss, loops must be adjusted for identical coupling. See text for discussion and methods of making these adjustments.

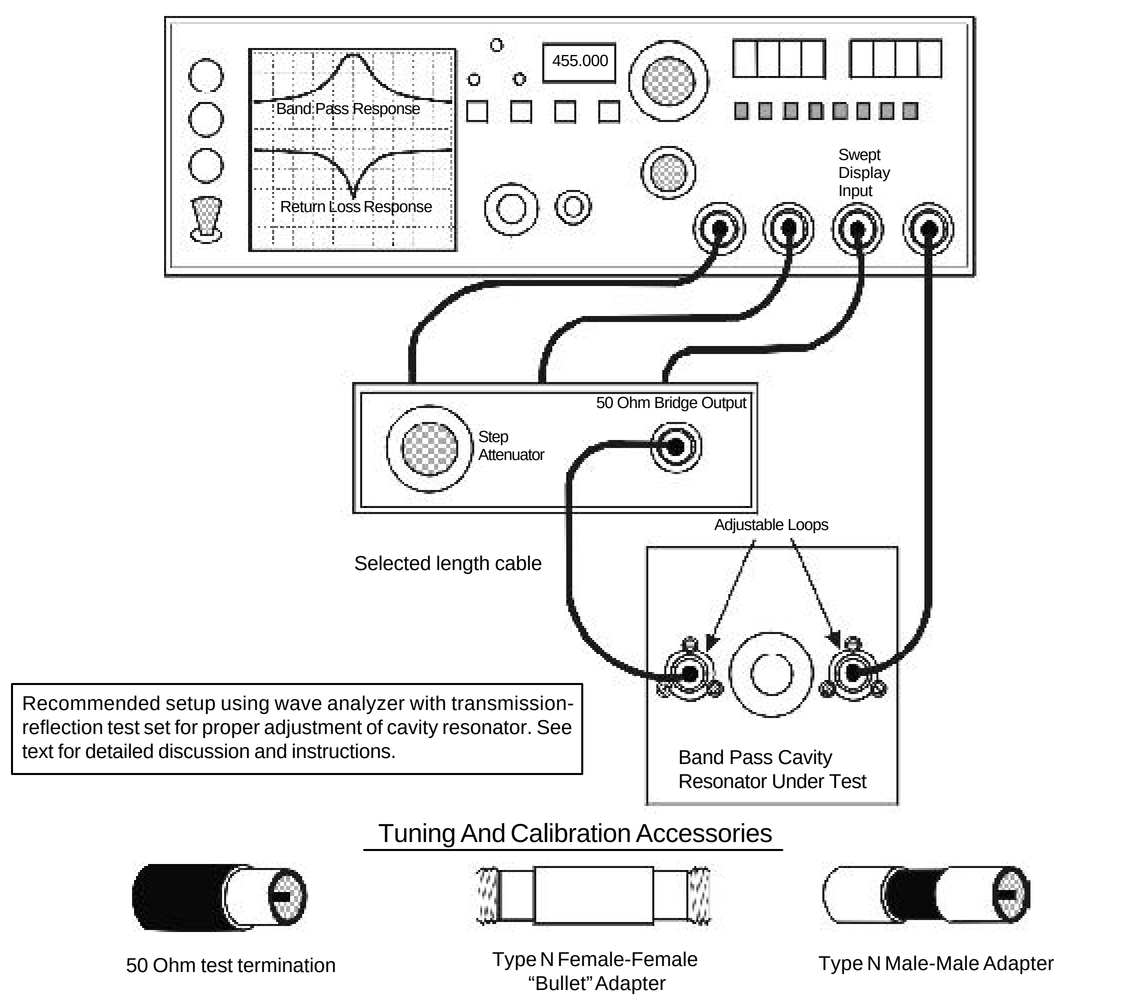
the mismatch condition to result in errors in displaying the return loss at the cavity port. Identical, specially constructed cables must be used to the DUT from bridge and from the DUT to the swept display input of the wave analyzer. More on this later.

The analyzer will simultaneously display two important parameters: Signal gain or loss and return loss. The analyzer must be adjusted to a suitable swept range of frequencies such that these parameters are displayed in a format suitable to arrive at proper adjustment. It is also possible to use a spectrum analyzer with a sweeping generator and an external return loss bridge for this procedure.

Having the ability to see the return loss at each port as you adjust the loops is most important to arriving at a balanced loop adjustment. The setting of both loops must be identical, as the best selectivity of the cavity can be realized at a selected loop only when this balance exists. Displaying the return loss when driving each cavity port is the only way to see relationship.

Figure 5 shows a wave analyzer equipped with a matching Transmission-Reflection Test Set

Figure 5



Recommended setup using wave analyzer with transmission-reflection test set for proper adjustment of cavity resonator. See text for detailed discussion and instructions.

organized with test cables connected to a band pass cavity. At EMR, we set up our analyzer with the return loss trace referenced to the center of the display and the vertical response trace is calibrated to the top of the scale. This provides an 80 dB response range for forward signals and a 40 dB range loss display. This set-up will yield the least amount of confusion in viewing these two inter-related parameters.

To build up a proper set of test cables the lengths must first be calculated and the length compensated by the velocity factor of the cable. In this example we will use a frequency of 455 MHz, to which we will cut a 1/2 wavelength test cable made of RG142B/U. The 1/2 wavelength is 12.3 inches and the cable velocity factor is 80%, making the cable length 9.9 inches. The effective length of two Type N connectors of 7/16" each must be deducted for a net cable length of 9.0". It is best to make up your cables using "clamp" type connectors, making the cable a bit long, then shortening it experimentally to center its return loss at the center of the desired frequency range when terminated by a 50 ohm test load termination known to have a 40 dB or greater return loss. With the cable connected directly to the analyzer's R.F. bridge the measured return loss should be 35 dB or better at the center of the band of interest. Once the length has been determined, make a matching cable to use from the DUT to the analyzer's swept measurement input jack.

Where you will be routinely working on cavities, isolators and other devices, in the popular frequency bands, it is a good idea to make up and label a set of cables for each band. it is most important that correct test cables are used since the validity of your measurements can only be assured with proper instrument calibration and correct cable lengths.

Tuning & Adjusting Band Pass Cavity Resonators

In the following example we will adjust a 4" square band pass cavity for 1.0 dB coupling loss at exactly 455.000 MHz. Note that this procedure will apply to most band pass cavities, regardless of the size or manufacturer. It is assumed, however, that any such cavity will be equipped with rotating adjustable loops. The recommended procedure is as follows:

1) Set the analyzer to display response relative to a selected center frequency. Set the frequency to 455 MHz. and the displayed swept bandwidth to 10 MHz.

2) Connect the ends of the test cables together using the "bullet" adapter. You should see a return loss of at least 26 dB at screen center. If lower than 26 dB you should adjust cablelengths as needed to provide at least 26 dB (1.1:1 VSWR) and preferably 35 dB or more (1.03:1 VSWR).

3) With the cables connected in this manner set the analyzer "B" channel resolution to 0.25 dB per graticule division. Adjust the display positioning to place the gain/loss trace at exactly "0" dB (at the top line of the graticule).

4) Set each of the loops to approximately 0.7 dB of coupling (rotated about 30 degrees counter clockwise from the full coupling position).

5) Connect the cable from the R.F. Bridge to one cavity port and the other cable to the 2nd cavity port (see Figures 4 & 5). Set analyzer channel "B" resolution to display 10 dB per vertical division. Expand the analyzer bandwidth until you can identify the cavity response and adjust the tuning rod to tune it to center of the screen then reduce the swept range to 20 MHz. total (1 MHz. per horizontal

division). Reset cavity tuning response to center on exactly 455 MHz.

6) Now observe the return loss and insertion loss indications. The return loss could be anything from 5-6 dB, and the insertion loss from 0.7 to 5 or 6 dB. Loosen the loop plate hold down screws on the cavity port being driven out of the bridge and slowly rotate the loop until a return loss of 18-20 dB is indicated.

7) Exchange the cable so that you are driving and monitoring opposite ports. Again, adjust the return loss of the driven port for 18-20 dB indication. Now observe the indicated insertion loss with the “B” vertical resolution set to 1 dB per division. Let’s say that it is about 1.1 dB. This tells you that you must adjust the coupling factor of <u>both loops</u> to provide the target insertion loss of 1.5 dB.

8) As you make fine adjustments, you must always keep track of the last loop that was adjusted or you will probably have to start over again, from scratch! Optimum settings can best be secured by adjusting the driven loop only, while observing both the return loss and the insertion loss, then exchanging driven and monitored loops until the target insertion loss has been secured with identical return loss indication at both ports.

At first, you might have to make six or seven cable-loop exchanges to arrive at the target characteristics! With experience, however, you should be able to arrive at target adjustment in two or three tries. Once you have arrived at balanced insertion loss settings for both ports you will find that measured insertion loss is independent of which port is being driven or monitored. You will also see that for any given cavity, the best symmetrical response will result and the best selectivity will be provided when loop return losses are matched.

It is often asked, “Why can’t I get 35-40 dB of return loss at both ports of a cavity?” The reason is that the loops present an inductive characteristic, which when compared to a purely resistive 50 ohm impedance measure device, such as the bridge of the transmission-reflection test set, shows an *admittance* of +j30 or higher. This may be readily displayed through polar analysis or Smith Chart display for those familiar with these methods of phase vs: reactance and resistance display methods. It will be found that where multiple cavities are cascaded the overall return loss can be improved somewhat through careful connecting cable and loop adjustment manipulation.

Tuning & Adjusting Pass Notch Cavities

Figure 6 shows the arrangement for tuning pass reject cavities. Adjustment and calibration of the wave analyzer is the same as for tuning band pass cavities. Note, however, that instead of observing one sharp peak of response you will find a relatively broad pass response and a sharply defined notch. The notch may be placed either above or below the pass band center through loop adjustment.

As shown in Figure 6, the analyzer sweep is centered at 485.000 MHz. with the swept range set to 10 MHz. wide. In this case the cavity is to be adjusted for a pass response at 483.500 MHz. and the notch at 486.500 MHz. The single loop has a series capacitor installed in its loop plate, as suggested in Figure 3. Procedure for adjusting the type of cavity is as follows:

1) Set the center swept frequency of the analyzer to the desired <u>pass</u> frequency and calibrate as outlined in <u>Tuning & Adjusting Band Pass Cavity Resonators</u>, steps 1 through 3.

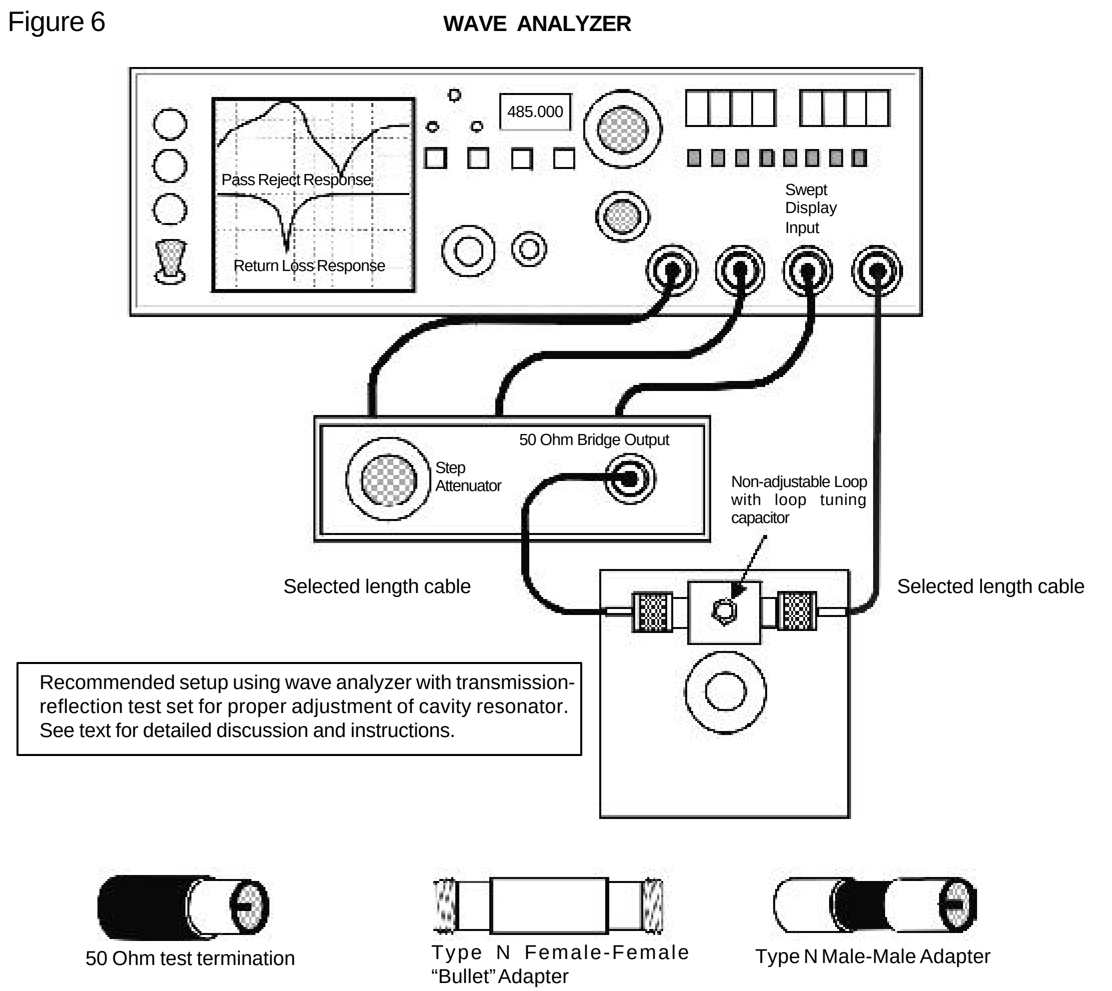
2) Connect cable as shown in Figure 6. Expand the swept range until you can identify

the notch response of the cavity and adjust the tuning rod to center this on the screen. Reduce the swept width such that the pass and notch responses are well defined.

3) Adjust the loop tuning capacitor to show a symmetrical pass band with notches above and below. Loosen the loop fixing screws and rotate the loop. You will see that as loop coupling factor is reduced (toward higher loss) the two notches tend to move closer to the pass band frequency. Now, set vertical resolution to 1 dB per reticule division, set cavity on frequency and observe the insertion loss. It can be from a few tenths of a dB to 2 dB. Rotate the loop for a loss of 0.6 dB.

4) You can now adjust the loop tuning capacitor to place a notch either above or below the pass band. You will notice that as the notch approaches the pass frequency the notch depth diminishes. For example, with an EMR Corporation 4" square pass reject 440-512 MHz. range cavity a notch of 40 dB or more can be secured between 4 and 7 MHz.

Figure 6



Tuning And Calibration Accessories

above or below the pass frequency, with 0.3 dB on-frequency insertion loss setting. See Figure 8 for typical responses.

The size of the cavity, e.g.: cross sectional areas, the material used, loop size, loop positioning and pass-to-notch relationship will all influence the notch depth vs: insertion loss performance. With proper loop design a return loss of at least 18 dB should be found at usable pass-to-notch settings.

Pass reject cavities are used in many ways in the land mobile business. Perhaps the most prevalent usage is in band pass-band reject type antenna duplexers. In most cases two or three cavity elements are cascaded using selected cable lengths in each branch of the duplexer. Other applications include single, dual or even triple pass reject cavities used to protect a receiver front end from overload due to a nearby high power transmitter carrier. Similarly, such filters may be tuned to trap out wide band transmitter noise that would otherwise "clobber" a nearby receiving system.

Behavior of Multiple Cavity Combinations

Multiple band pass and multiple pass reject cavity assemblies are used, as mentioned earlier, to meet extreme filtering requirements. Figure 7 provides typical performances of single band pass cavities adjusted to various coupling factors compared with assemblies of two and three series cavities. Figure 8 shows the response of a single cavity at various pass-to-notch relationships and for the response of three cavities, all adjusted for maximum notch performance.

Let's say that we wish to reject a strong transmitter carrier that is 2 MHz. lower than a receiver's frequency of 456.000 MHz., as well as other carriers that are between 3 and 6 MHz. higher in frequency. Using a step attenuator, we determine that placing 30 dB of attenuation at the receiver's input solves the interference problems but destroys the receiver's on channel sensitivity. However, adding only 2 dB of attenuation appears to have no noticeable effect on the on-channel performance of the receiver when the interference is not present. The decision in this case is to use a triple band cavity filter between the receiving antenna and the receiver's input.

Looking at Figure 7 we find that a triple cavity assembly having 1.5 dB of loss will provide 35 dB of attenuation at 2 MHz. and almost 55 dB at 4 MHz. from its center tuned frequency. The result: needed sensitivity of the receiver is retained and interfering signal carriers are attenuated below levels that previously caused interference. However, we find that the transmitter operating 2 MHz. lower in frequency still provides noise to our receiver each time that it operates.

We decide to use a dual pass reject cavity pair installed between the offending transmitter and its antenna. Tuned with 0.7 dB of loss, transmitter signal power reduction is undetectable in the field and transmitter noise at 454.000 MHz. is no longer a factor as it is rejected by 70 dB or more. These are only two typical applications for pass and reject cavities in practical situations. When the capabilities of these devices are properly applied, such problems may be readily solved.

When assembling multiple cavity filters the jumper cables are very critical. Just any old cable length will usually not work! The cable length required to couple cavities together must be chosen such that the cavity characteristics are *repeated* from each cavity to the next one in line. In most cases this turns out to be a length that simulates a 1/2 wavelength at the frequency concerned; plus or minus a matching length to compensate for effective loop and connector electrical lengths and the velocity factor of the cable to be used.

Since effective loop electrical length varies as depth of coupling into the cavity is changed, adjusting the coupling factor of the cavity might result in a required change of cable length to secure proper matching. This is true with both band pass and pass reject cavity combinations. Band pass characteristics may be broadened to provide flat pass responses with steep skirts, in required system applications. A combination of cable length modification and "trick" loop adjustments are required to produce these effects. As pass bands are widened, a number of cavities might be required resulting in a complex project of cable length and coupling loop manipulation.

We are often asked to list generic cable lengths needed to tie cavities together. Often, these might be intended for use on mixed brands of cavities having individual electrical characteristics and for which we may not have file information. Generally, we can only give the customer a hint at such cable lengths because there are many other considerations that must be taken into account in their derivation. Here at EMR Corporation, we have developed families of cable lengths to suit various multiple filter and duplexer requirements in the various bands. These lengths relate specifically to the characteristics of our own cavity designs, known connectors and cable characteristics and the traditional ranges of operating bands found in the land mobile business. Some of these lengths may work with other makes of cavities, provided that a similar circuit design is used. Where new or "first time" applications come up we usually generate the expected lengths from available file information or develop them from formulas and adjust to compensate for the various factors that influence this technique. Of course, experience helps a lot! Still, we have a collection of test cable lengths that we use for trial cable-up when special filtering projects come up.

Tuning Cavities With Other Test Equipment

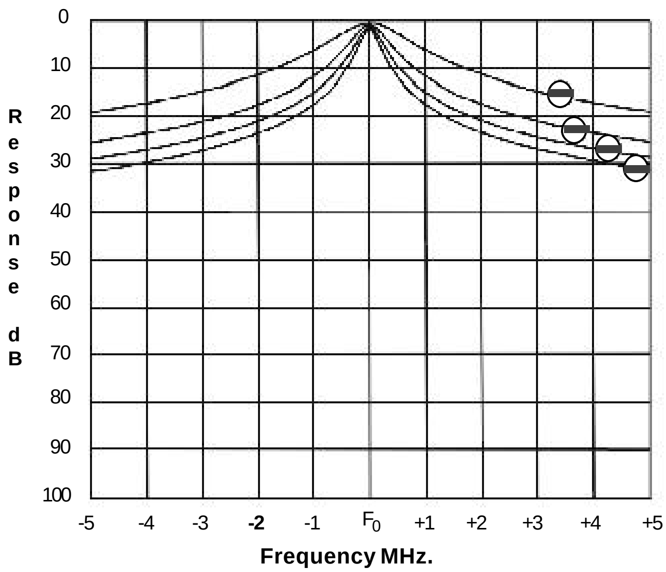
Although the luxury of having a wide dynamic range wave analyzer is the best situation when working with filters, other combinations of equipment will serve the purpose. Some of these are:

Spectrum analyzer with built-in or external synchronous swept source generator. Acceptable results can be obtained with an accessory return loss bridge between the generated signal output ant the DUT.

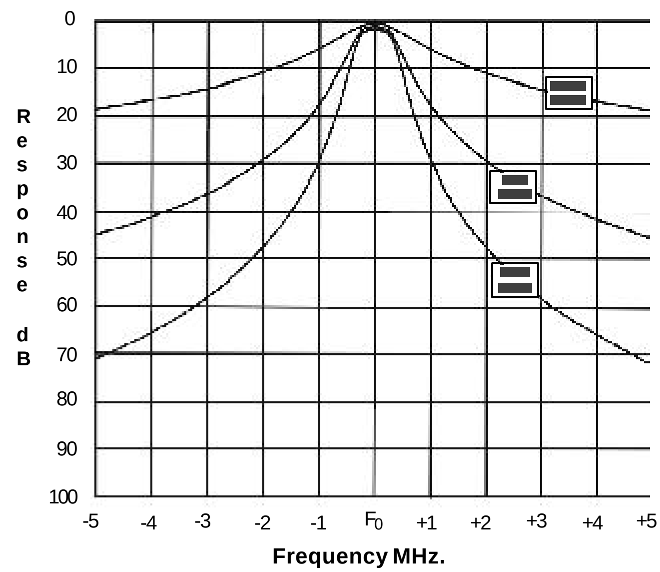
Advanced type service monitors having tracking generator capability. Accessory bridges will provide the return loss measuring capability such that correct cavity adjustment is possible.

Summary

It is hoped that this write-up has explained some of the mysteries of cavity resonators and their applications as filter components. Should the reader have special requirements or special problems, we will be pleased to be of assistance in any way possible.

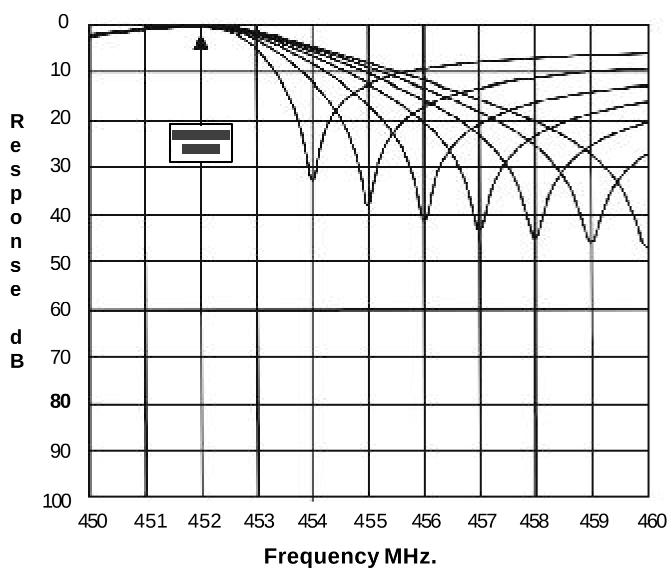


Selectivity characteristics of UHF 7" square band pass cavity at four throughput loss loop adjustment settings.

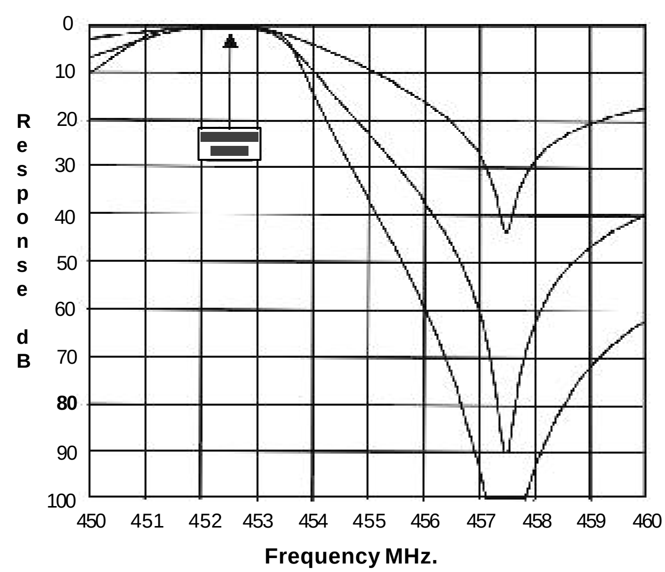


Selectivity characteristics of one, two and three UHF 7" square band pass cavities in series, each set at 0.5 dB loss.

FIGURE 7



Response of one UHF 4" square pass reject cavity when adjusted for pass and notch spacings of 2, 3, 4, 5, 6, 7, and 8 MHz.



Responses of one, two and three series pass reject UHF 4" square cavities @ 5 MHz. spacing.

FIGURE 8

Behavior of single and multiple resonator combinations adjusted in different manners. See text for additional discussion.

EMR corp.
ELECTROMAGNETIC DESIGNS AND CONSULTING SERVICES
FOR THE TWO-WAY COMMUNICATIONS INDUSTRY
17431 N. 25th AVENUE - PHOENIX, ARIZONA 85023
TEL: 623-581-2875 - FAX: 623-582-9499

DECIBELS vs. POWER

dB	Power Ratio		dB	Power Ratio		dB	Power Ratio	
	Gain	Loss		Gain	Loss		Gain	Loss
0.1	1.023	.9772	3.5	2.239	.4467	6.9	4.898	.2042
0.2	1.047	.9550	3.6	2.291	.4365	7.0	5.012	.1995
0.3	1.072	.9333	3.7	2.344	.4266	7.1	5.129	.1950
0.4	1.097	.9120	3.8	2.399	.4169	7.2	5.243	.1906
0.5	1.122	.8913	3.9	2.455	.4074	7.3	5.370	.1862
0.6	1.148	.8710	4.0	2.512	.3981	7.4	5.495	.1820
0.7	1.175	.8511	4.1	2.570	.3891	7.5	5.623	.1778
0.8	1.202	.8318	4.2	2.630	.3802	7.6	5.754	.1738
0.9	1.230	.8128	4.3	2.692	.3715	7.7	5.888	.1698
1.0	1.259	.7943	4.4	2.754	.3631	7.8	6.026	.1660
1.1	1.288	.7763	4.5	2.818	.3548	7.9	6.166	.1622
1.2	1.318	.7586	4.6	2.884	.6467	8.0	6.310	.1585
1.3	1.349	.7413	4.7	2.951	.3389	8.1	6.457	.1549
1.4	1.380	.7244	4.8	3.020	.3311	8.2	6.607	.1514
1.5	1.413	.7080	4.9	3.090	.3236	8.3	6.761	.1479
1.6	1.445	.6918	5.0	3.162	.3162	8.4	6.918	.1445
1.7	1.479	.6761	5.1	3.214	.3090	8.5	7.079	.1413
1.8	1.514	.6607	5.2	3.311	.3020	8.6	7.244	.1380
1.9	1.549	.6457	5.3	3.388	.2951	8.7	7.413	.1349
2.0	1.585	.6310	5.4	3.467	.3884	8.8	7.586	.1318
2.1	1.622	.6166	5.5	3.548	.2818	8.9	7.762	.1288
2.2	1.660	.6026	5.6	3.631	.2754	9.0	7.943	.1250
2.3	1.698	.5888	5.7	3.715	.2692	9.1	8.128	.1230
2.4	1.738	.5754	5.8	3.802	.2630	9.2	8.318	.1202
2.5	1.778	.5623	5.9	3.891	.2570	9.3	8.511	.1175
2.6	1.820	.5495	6.0	3.981	.2512	9.4	8.710	.1148
2.7	1.862	.5370	6.1	4.074	.2455	9.5	8.913	.1122
2.8	1.905	.5248	6.2	4.169	.2399	9.6	9.120	.1097
2.9	1.950	.5129	6.3	4.266	.2344	9.7	9.333	.1072
3.0	1.995	.5012	6.4	4.365	.2291	9.8	9.550	.1047
3.1	2.042	.4898	6.5	4.467	.2239	9.9	9.772	.1023
3.2	2.089	.4786	6.6	4.571	.2188	10.0	10.000	.1000
3.3	2.138	.4677	6.7	4.677	.2138			
3.4	2.188	.4571	6.8	4.786	.2089			