BELLSOUTH

BellSouth Corporation
Suite 900
1133-21st Street, N.W.
Washington, D.C. 20036-3351

karen.possner@bellsouth.com

Karen B. Possner
Vice President-Strategic Policy

202 463-4160
Fax 202 463-4637

April 4, 2002

By Electronic Filing

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
445 12th St., N.W.
Washington, D.C. 20554

Re: Ex Parte Submission
Establishment of Rules and Policies for Satellite Digital Audio Radio Service in the 2310-2360 MHz Band, IB Docket No. 95-91

Dear Mr. Caton:

This letter responds to certain statements in letters filed by XM Radio, Inc. ("XM") and Sirius Satellite Radio, Inc. ("Sirius") on March 28, 2002 and April 1, 2002,[1] that are important to the Commission's decision in this proceeding. BellSouth does not concede other statements in those letters but believes it has addressed them in earlier BellSouth and WCS Coalition filings.

With their March 28 filing, XM/Sirius included a technical study and price quotation from TFR Technologies, Inc. to support their claim that filters for WCS-band CPE that adequately suppress SDARS interference are easily obtainable and inexpensive. They say, "TFR Technologies…can produce thin film resonator filters providing 20 dB of rejection for WCS CPE operating in all of the WCS bands, and that these filters will cost no more than $25 each in sample quantities."[2]

BellSouth obtained a copy of this study from TFR prior to March 28, 2002. It also discussed the paper with Mr. Lakin, President of TFR and the author of the paper. On the basis of that discussion, Mr. Lakin concluded that his paper needed to be clarified to avoid

[1] Letter from Patrick L. Donnelly and Lon C. Levin to William F. Caton, IB Doc. No. 95-91 (Mar. 28, 2002) ("XM/Sirius March 28, 2002 Letter"); Letter from Patrick L. Donnelly and Lon C. Levin to William F. Caton, IB Doc. No. 95-91 (April 1, 2002) ("XM/Sirius April 1, 2002 Letter").
[2] XM/Sirius March 28, 2002 Letter, p. 3.

possible misinterpretation. Consequently, he provided a Statement regarding his analysis and conclusions (Attachment 1, "Lakin Statement"), and a revision to the TFR paper relied on by XM and Sirius. (Attachment 2, "Filters for WCS Receivers").

These materials now clearly demonstrate that the filters shown in the paper do not meet the performance requirements necessary for WCS equipment to operate in the WCS band. The 3 dB mid-band loss and 10 dB band-edge loss of these filters (Lakin Statement, Attachment 1) are far outside the acceptable range for WCS in-band and band-edge loss. If used in an attempt to protect WCS CPE against blanketing interference from XM/Sirius repeaters, the filters would destroy the noise figure performance of even the most modern WCS receiver.

Thus, TFR's analysis supports BellSouth's position that -- filters that provide adequate in-band performance for WCS and sufficient protection against the harmful interference created by the SDARS terrestrial repeaters cannot be produced at low price. Conversely, a low priced filter for WCS CPE either will fail to meet in-band performance requirements or SDARS interference suppression requirements.

BellSouth also attaches a statement from K&L Filters, another respected manufacturer, drawing the same basic conclusion. K&L shows that filters that do meet both the in-band performance requirement and the SDARS interference suppression requirement are far too expensive for use with WCS CPE. (Attachment 3).

In their April 1, 2002 filing, XM and Sirius contend that the BellSouth coverage studies from November 2, 2001 do not include RF AGC because the results "logically could flow only if" such analysis did not include RF AGC.[3] In fact, the study does include the effects of RF AGC (the "front-end AGC is already incorporated in most well designed WCS receivers").[4]

XM and Sirius also contend that they used – 80 dBm for receiver sensitivity in their reply to BellSouth's November 2, 2001 coverage analyses. BellSouth now sees that – 80 dBm was used for this particular parameter and understands how it arrived at its erroneous assumption. BellSouth notes that XM and Sirius also changed the confidence level for the interfering signal and the intermodulation threshold from the numbers supplied by BellSouth. By changing such key parameters, XM and Sirius were able to make it appear as if the interference disappeared. BellSouth, on the other hand, relied on actual manufacturers' specifications and realistic assumptions for predicting interference and to evaluate RF AGC performance.

---

[3] *Id.*, p. 2.
[4] Letter from Randall Schwartz to Magalie Roman Salas, IB Doc. No. 95-91 (Nov. 2, 2001), Attachment entitled "Response to XM Radio's Supplement to August 29, 2001 White Paper," p. 3.

XM and Sirius next contest BellSouth's stated belief that the SDARS operators coordinated their repeater power to facilitate operation of their RF AGC systems. BellSouth based its statement on a discussion between Paul Marko of XM and Neale Hightower on August 30, 2001 in conjunction with a meeting at the Commission. Mr. Hightower asked how XM and Sirius had been able to protect their own customer receivers from overload and intermodulation interference, given the frequency and transmit power of their repeaters. Mr. Marko responded that the operators had coordinated their repeater deployments and power levels to avoid widely disparate CPE receive levels in order to "make it work."

The SDARS licensees also challenge BellSouth's comments regarding the use of 40 kW omni-directional repeaters. BellSouth is aware that XM and Sirius do not necessarily operate omni-directional 40 kW repeaters today, and that is why it referenced their use of sectorized antennas. However, to the extent a Commission rule would permit them to use omni-directional antennas, or three adjacent 120 degree sectors at the same location, they could create the same effect. That possibility is relevant to this proceeding and demonstrates the full potential for harm to the WCS licensees.

In their April 1, 2002 filing, XM and Sirius claim that the "tests" with a single WCS licensee—AT&T Wireless—are in the record and answer BellSouth's questions.[5] Their March 18, 2002 filing refers to other "significant representative testing."[6] If there is only one set of "field tests," with one WCS licensee, in one location, with one set of parameters, *a fortiori*, this is not significant testing or representative testing, and the record does not support their claim. Indeed, Exhibit A to XM's December 14, 2001 filing indicates XM tested only 5110 W or 5 kW.[7] This is below the power cap XM and Sirius reject and, therefore, clearly does not support their contention that operations above the 5 kW level can be conducted without significant interference to WCS CPE.

Please refer any questions regarding this matter to the undersigned.

Sincerely,

---

[5] XM/Sirius April 1, 2002 Letter, p. 4.

[6] Letter from Carl R. Frank and Bruce D. Jacobs to William F. Caton, IB Doc. No. 95-91 (Mar. 18, 2002), p. 3.

[7] Comments of XM Radio, IB Doc. 95-91 (Dec. 14, 2001), Exhibit A, p. 2.

Attachments

cc: Donald Abelson
Thomas Sugrue
Edmond Thomas
Bruce Franca
Peter Tenhula
Samuel Feder
Paul Margie
Bryan Tramont
David Furth
Ronald Netro
Richard Engelman
Ronald Repasi
Julius Knapp
Bruce Jacobs (counsel for XM)
Carl Frank (counsel for Sirius)

April 2, 2002

STATEMENT

On March 28, 2002, XM Radio and Sirius Satellite Radio apparently jointly filed an Ex Parte with the FCC wherein they attached a white paper and quotation that TFR Technologies, Inc. had previously prepared for them.

In the copy of the filing provided to TFR Technologies, Inc, the authors state that "Attached hereto is a report from a well-regarded filter manufacturer, TFR technologies, Inc., concluding that it can produce thin film resonator filters providing 20 dB of rejection for WCS CPE operating in all of the WCS bands, and that these filters will cost no more than $ 25 each in sample quantities."

That brief summary statement may be potentially misleading to the reader. The design simulations (Figure 2 of my white paper, "Filters for WCS Receivers", 3/22/2002, revised version attached.) showed a clear tradeoff between WCS in-band filter characteristics and rejection levels in the SDARS bands. The simulated filter having 20 dB of attenuation in SDARS band also showed 3 dB of loss in the WCS mid band and up to 10 dB attenuation at the WCS band edges. WCS receivers operating in this band with that specific front-end filter could experience an unacceptably degraded noise figure and thus, with high probability, unacceptable to the WCS manufacturer.

The general issues of filter design and the consequences of less than ideal filter performance have been discussed verbally with Mr. Marko of XM and others.

Attached is a revised version of the paper I have produced which specifically points out these facts, including my professional opinion that a low cost filter that provides likely acceptable performance for WCS and high SDARS rejection cannot be built at this time.

Our standard quote to XM for a filter prototype stated a wafer run cost of $4000 and a piece part cost of $25 for test and packaging. Thus, if the wafer yield is only 100 filters, about 10% yield, the wafer run itself contributes $40 to the filter cost on top of the $25 for test and packaging for an effective cost of $65. Our perceived level of technical risk is reflected in the statement "Note: This work will be performed on a "best effort basis" by TFR". Filter costs for high volume manufacturing are not known at this time.

Kenneth M. Lakin, President
TFR Technologies, Inc.

Filters for WCS Receivers

White Paper

Prepared by,

Kenneth M. Lakin
TFR Technologies, Inc.
Bend, OR 97701
PH: 541-382-6706
FAX: 541-382-7783
E: klakin@aol.com
www.tfrtech.com

This paper is a preliminary report on the potential for using the thin film bulk acoustic wave resonator technology to synthesize filters for the WCS band. The filters would used to protect WCS receivers from intense nearby signals generated by SDARS or other adjacent spectrum users. **The goal is a front end filter, to be placed between the antenna and low noise amplifier (LNA), having low insertion loss (< 2 dB) to preserve signal to noise ratio, sharp corners to preserve the WCS bandwidth, and high rejection (>30 dB) in the SDARS bands to protect the LNA from overload**.

As preliminary background, TFR Technologies, Inc. specializes in the manufacture of high performance filters for military and civilian applications [1]. The company has filters being used in a number of radar systems and Army radios and manufactures nearly 200 filters for frequencies in various bands between 500 MHz and 12 GHz using the thin film crystal resonator technology.

Figure 1 shows the general spectrum of the WCS/SDARS band and the allocations [2]. These frequency distributions were used in the simulations of WCS band filter responses. From a filter implementation standpoint the most critical feature is the narrow bandwidth (0.17%) of the separation between the WCS and SDARS bands. The ideal filter for the WCS receiver would have a low insertion loss at the WCS band edge and drop steeply to a desired floor within that 4 MHz bandwidth. The extent to which such an ideal filter response can be realized is dependent upon the amount of attenuation drop required and the intrinsic Q of the core resonator technology used to implement the filter.

Resonator Q has a primary affect on in-band insertion loss, filter skirt selectivity, and sharpness of pass band edges. The number of poles in a filter design affects the steepness of the skirt selectivity but can progressively degrade in-band insertion loss, and can incrementally round the passband edges. Accordingly, the level of rejection obtainable with a finite Q resonator technology is the result of a tradeoff between insertion loss, bandwidth, and near-in rejection level.

In cell phone base station applications is well known that high performance can be achieved with large air dielectric microwave cavity resonators or with superconducting resonator based filter configurations. The size and cost of such filters generally limits their use to less cost sensitive applications and precludes their use in subscriber sets where size and cost are major issues.

Figure 2 and 3 are simulations of filter responses designed for WCS receivers. The assumptions in the design are; 1) the filter is to be used between the antenna and low noise amplifier (LNA), 2) the insertion loss of the filter should be as low as possible to maintain a low noise figure, 3) the near-in rejection should be as large possible to protect the receiver from front end overload caused by nearby SDARS transmitters. Finally, the designs shown are only for illustration, have not been optimized, yet are considered as obtainable in practice with the thin film crystal resonator technology.

The filters used for this design consists of T network sections wherein each T network is composed of series and shunt crystal resonators. These filters can be implemented with thin films in a process described in a number of papers on the company web site. The design and manufacturing methodology allows for different ultimate rejection ratios.

Figure 2 shows the response of two compromise designs illustrating tradeoffs between in-band insertion loss, out-of-band rejection, and skirt selectivity. Clearly, the filter labeled ns=2 (two T sections connected in series) has excessive rounding of the band edge and increased insertion loss. Group delay is shown as a reminder of the effect that sharp skirt selectivity has on that parameter. Any level of attenuation can be designed between or outside the limits shown in Figure 2. The designs shown suggest reasonable limits based on our best modeling data of device performance.

The filters in Figure 3 are for each of the WCS bands but are each of slightly wider bandwidth than the filter in Figure 2. Increased bandwidths will progressively decrease the skirt selectivity.

The responses shown in Figures 4 and 5 are for production filters made by TFR Technology for commercial applications. The filter in Figure 4 has a bandwidth and skirt selectivity similar to that required for the WCS receiver. However, the insertion loss is too great for the filter to be used in the front end so this filter is used after the LNA. A filter having less aggressive skirt selectivity is used ahead of the LNA but requires the LNA to be of a special design having high overload capability. Four of these filters are required in the receiver in order to suppress SATCOM signals from transmitter antennas located in close proximity on the aircraft fuselage.

The filter response in Figure 5 illustrates the severe corner rounding and high insertion loss that results when narrow bandwidth and high out-of-band rejection is required. This filter is used in the IF string of a commercial spectrum analyzer where insertion loss is less objectionable.

Filter cost is most directly related to the measures required to achieve frequency set-on accuracy during manufacturing. The number of poles in the filter is less of a cost issue because these filters are fabricated in a microelectronics wafer scale parallel process. The number of poles only begins to affect cost if the device becomes large enough to move to the next larger package size. Generally, the smaller the filter die, the more die per wafer, and the lower the per die cost in manufacturing. The filters in Figure 4 and 5 a sold for approximately $100 in small quantities of 4000 or less per year. Higher volumes generally allow greater manufacturing efficiencies in wafer scale processing. The filters of Figs 4 and 5 are delivered in 1015 (100 mils x 145 mils x 30 mils) packages whereas filters for WCS could be placed in smaller 1206 or possibly 0603 packages for greater cost savings.

The conclusion of this study is that a front end filter, having low loss, sharp corners, and 30 dB of attenuation at SDARS, cannot be obtained with a reasonable cost filter technology.

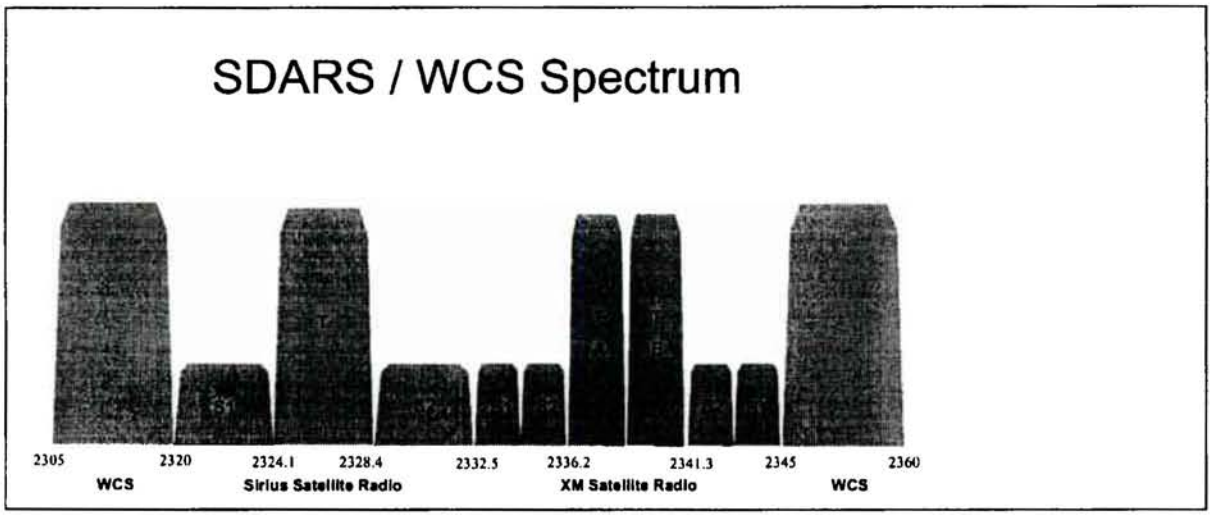


Figure 1. SDARS/WCS Spectrum showing frequency distribution. (Note that the frequency axis is non-linear with the SDARS bands emphasized.)

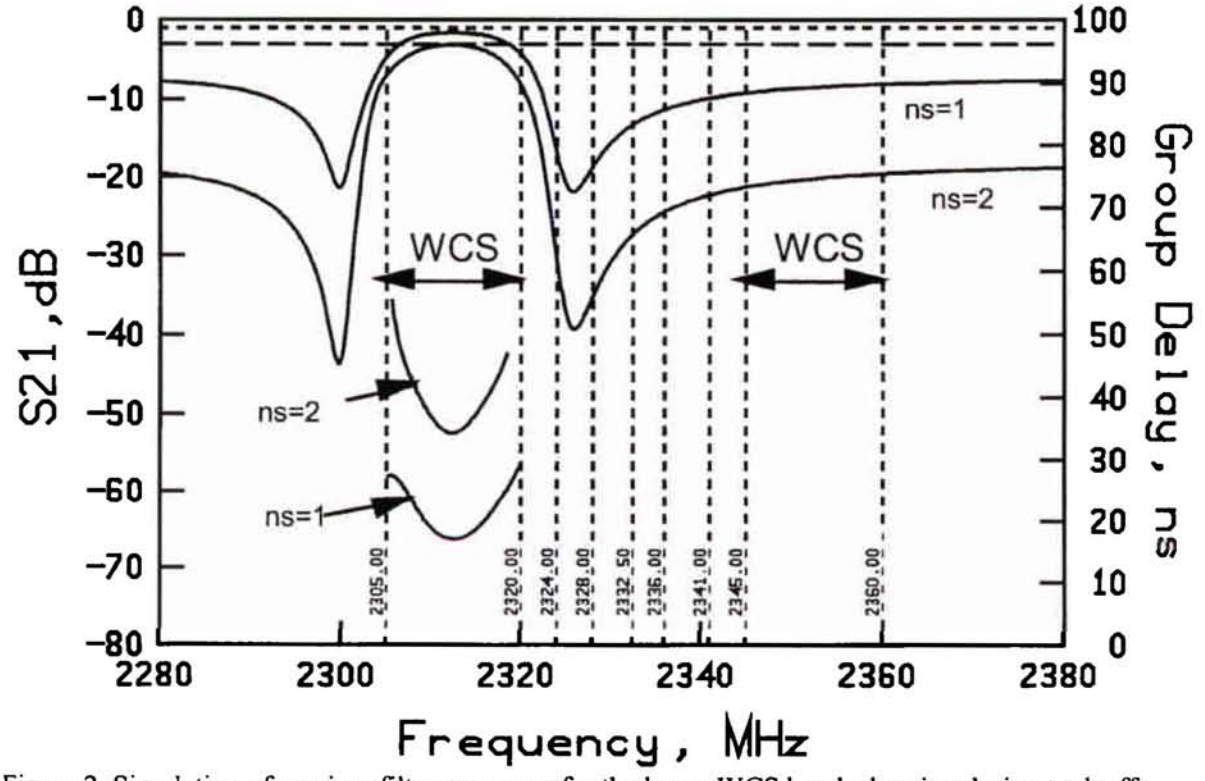


Figure 2. Simulation of receiver filter responses for the lower WCS band, showing design tradeoffs. The "ns" denotes the number of T network sections in the crystal ladder filter.

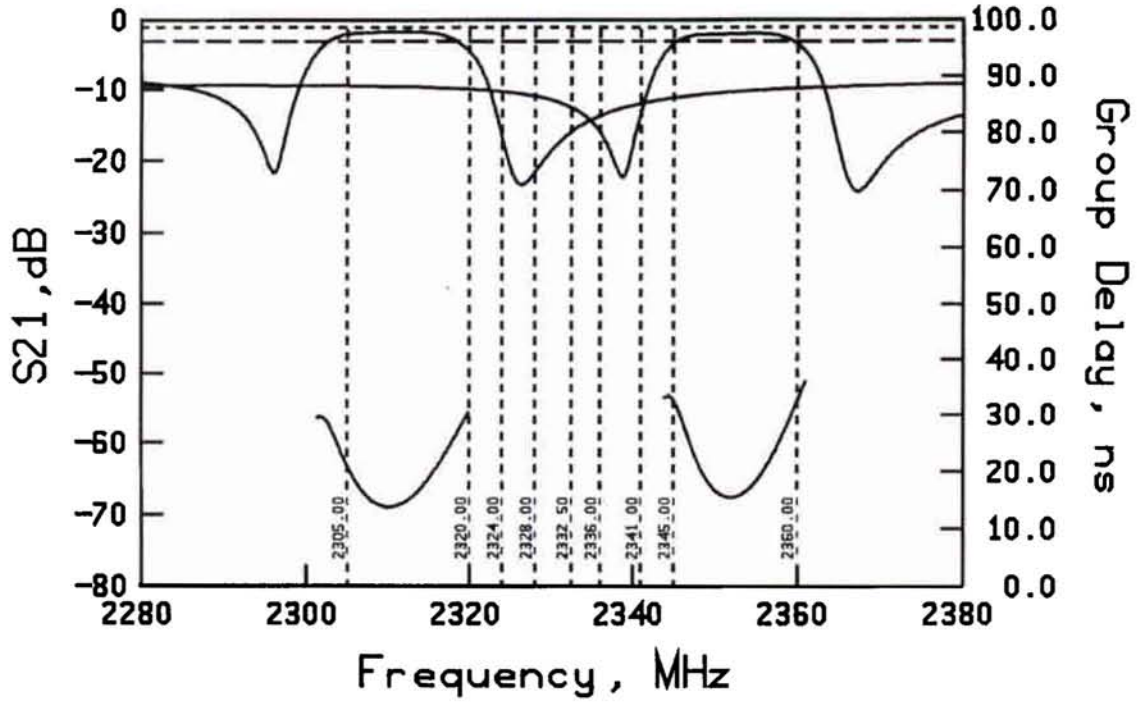


Figure 3. Two WCS filters having slightly wider passbands than those in Fig. 2.

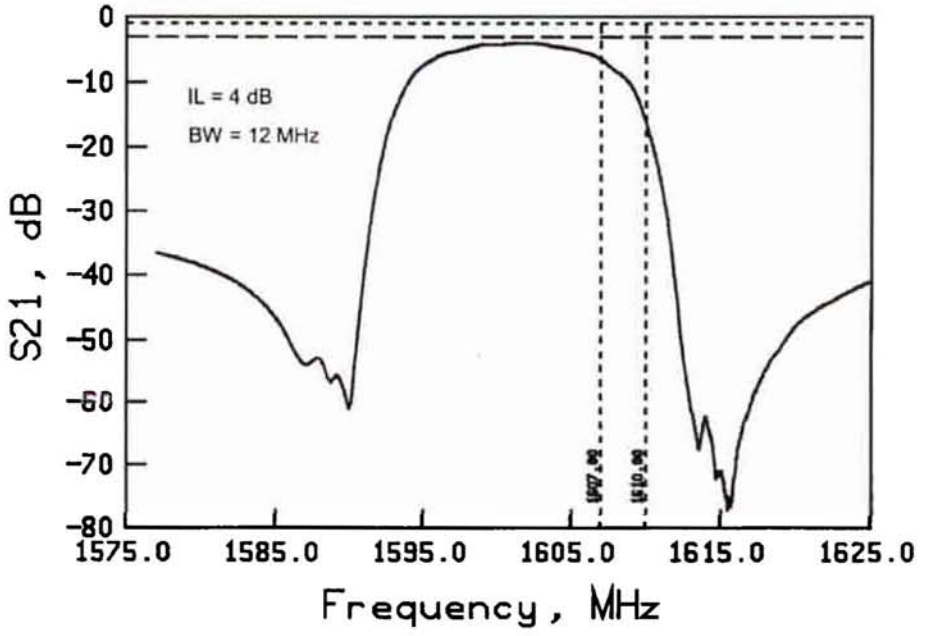


Figure 4. Production filter, made by TFR Technologies, used in an aircraft navigation system to protect the receiver from close proximity SATCOM transmitters.

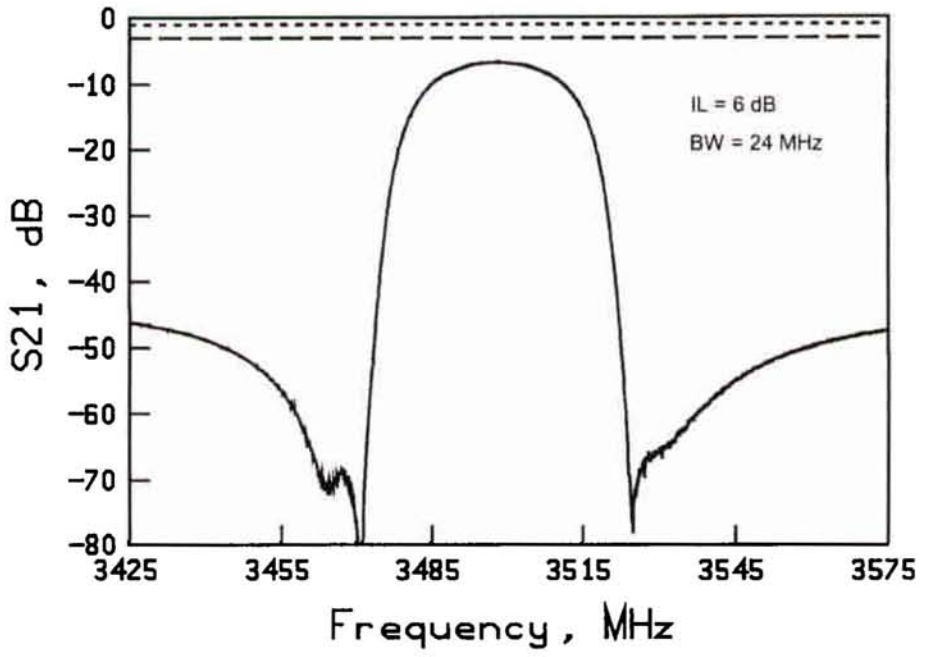


Figure 5. Production narrow bandwidth high skirt selectivity filter illustrating tradeoffs between out-of-band rejection, in-band insertion loss, and loss of signal at corner frequencies.

Reference:

1. A number of technical and review papers are provided on the TFR web site.
2. Chart provided by XM Satellite Radio

Attachment 3

-----Original Message-----
From: Wixon, Brian [mailto:BWixon@klmicrowave.com]
Sent: Tuesday, March 26, 2002 4:49 PM
To: Doug Duet (E-mail)
Cc: Donaway, Pat; Hoeler, Don; 'shamblin@bellsouth.net'
Subject: Filter Simulations

Doug,

Good talking to you on the phone this afternoon. Attached are the filter simulations described as follows.

BS23125.pcx

The is a five section very high Q (low loss) 2305 to 2320 MHz bandpass filter. We could offer 25 dB minimum rejection beginning at 2324 MHz and 0.75 dB max. passband insertion loss. Approximate size would be 7" x 4" x 2.5", excluding connectors. Cost would be high...approx. $500 each in 100's.

BS17MHZN.pcx

This a six section air cavity elliptic response notch filter. This notch filter would reject by 20 dB minimum from 2324 to 2341 MHz, with 1.5 dB maximum insertion loss from 2305-2320 MHz and 2345-2360 MHz. Approximate size would be 5.5"D x 4"W x 2.5"H, excluding connectors. Price would be modest, about 50% the price of the BS23125.pcx simulated part in similar quantities. This solution is superior to the two cascaded 4 MHz notch filters, being smaller in size and using fewer sections.

I think a $5 filter is out of the question! I was not able to use a ceramic resonator (PC board mount) filter solution with any sort of reasonable loss or flatness specification. At the very least it appears you need a cavity solution to keep the loss below 1.5 dB.

Please let me know if I can be of any further assistance.

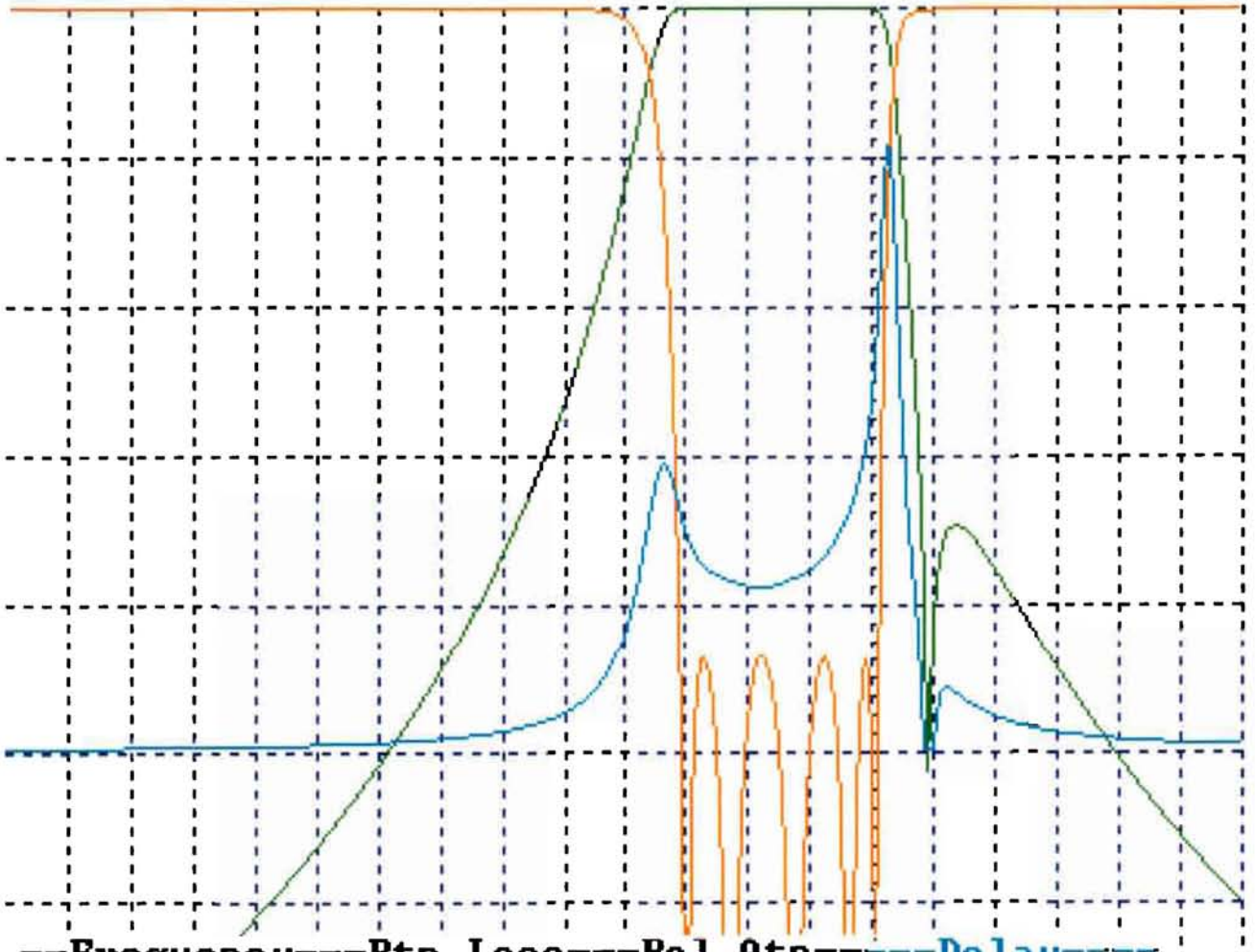
Best Regards,

Brian L. Wixon

Director, Wireless Infrastructure

K&L Microwave, Inc.

Phone (410) 749-2424, x3973



From 2250 MHz.
To 2350 MHz.
Marker = 2320.175

Atten. 10.000 dB/div.
Ref= 0.182351
0.416 dB
0.234 dB (Rel.)
Rtn loss 5 dB/div.
ref= 0 Delay %5.3f
33.976 dB
Delay 50.0 nSec/div.
ref= 250
130.844 nSec

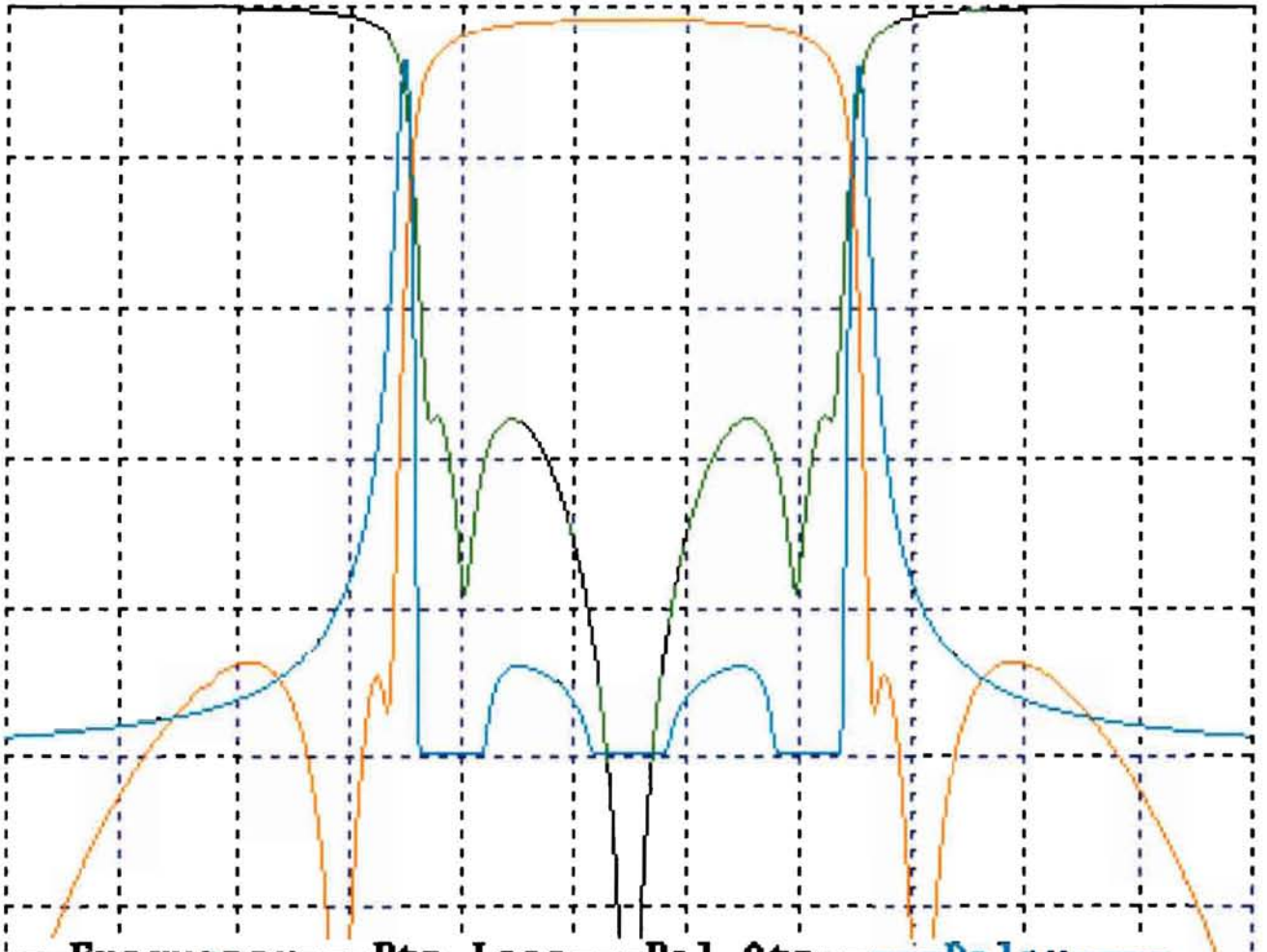
3.0 dB Bw 18.80 MHz.

1st div.= 2255 MHz.
MHz./div.= 5

Frequency	Rtn.Loss	Rel.Atn	Delay
2250.00 MHz.	0.0 dB	75.1 dB	0.8 nSec
2305.00 MHz.	34.3 dB	0.0 dB	72.8 nSec
2312.50 MHz.	26.4 dB	0.0 dB	57.1 nSec
2320.00 MHz.	34.0 dB	0.2 dB	130.8 nSec
2324.00 MHz.	0.1 dB	39.5 dB	-37.9 nSec
2350.00 MHz.	0.0 dB	60.2 dB	2.1 nSec

2255 2270 2285 2300 2315 2330 2345

Bell South WCS Filter - Typical Response
5DRPC-2312.5/E15.0, Q=20,000, b=2.0, 0.03BW=16.5, 2ppm



From 2305 MHz.
To 2360 MHz.
Marker = 2345.113

Atten. 10.000 dB/div.
Ref= 0.0895867
0.834 dB
0.745 dB (Rel.)
Rtn. loss 5 dB/div.
ref= 0 Delay %5 3f
33.684 dB
Delay 50.0 nSec/div.
ref= 250
56.128 nSec

3.0 dB Bw 20.95 MHz.

1st div.= 2305 MHz.
MHz./div.= 5

Frequency	Rtn.Loss	Rel.Atn	Delay
2305.00 MHz.	36.3 dB	0.0 dB	6.1 nSec
2320.00 MHz.	31.7 dB	0.8 dB	59.2 nSec
2324.00 MHz.	1.5 dB	27.4 dB	-27.7 nSec
2341.00 MHz.	1.6 dB	27.2 dB	-70.3 nSec
2345.00 MHz.	33.7 dB	0.7 dB	56.1 nSec
2360.00 MHz.	35.5 dB	0.0 dB	6.1 nSec

2305 2315 2325 2335 2345 2355

Bell South Notch Filter - Typical Response Low 4 MHz
6CN-2332.5/X17, Q=4340, b=1.5, 0.03BW=21, 5ppm