SIRIUS SATELLITE RADIO INC.
XM RADIO INC.

March 28, 2002

Via Electronic Filing
Mr. William F. Caton
Acting Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: *Ex Parte* Presentation
IB Docket No. 95-91

Dear Mr. Caton:

XM Radio Inc. ("XM Radio") and Sirius Satellite Radio Inc. ("Sirius") hereby respond to a March 22, 2002 letter filed by BeamReach Networks, Inc. ("BeamReach") in which it once again claims that the only remedy to potential interference to its WCS equipment is to limit satellite radio repeaters to 2 kW eirp. *See* Letter from Randall Schwartz, BeamReach Networks, Inc., to Willam F. Caton, FCC, IB Docket No. 95-91 (March 22, 2002) ("BeamReach Letter").

This latest submission further illustrates the difficult task both the Commission and the satellite radio licensees face in dealing with the last-minute claims of a company such as BeamReach that did not participate in the rulemaking until May 2001, four years after it began, and which makes assertions about equipment which it is apparently still designing and has not yet deployed. As discussed further below, BeamReach, which has never submitted verifiable technical specifications for its equipment or submitted the equipment to interoperability tests, continues to:

- present inconsistent and misleading information,
- fails to take any responsibility for its own poor design,
- has apparently withheld information that its base stations are not susceptible to interference from satellite radio repeaters,
- criticizes legitimate field tests that XM Radio has done with a WCS licensee even though those results were certified by the WCS licensee,
- criticizes the assumptions in an interference analysis even though it supplied those very assumptions,
- makes wildly exaggerated claims about the cost of filters for CPE, and
- is now attempting to completely re-engineer the SDARS licensees' receivers and repeater networks. The SDARS licensees' satellites and terrestrial repeaters have, of course, been designed, constructed, and are serving the listening public.

Below, XM Radio and Sirius refute each of the points BeamReach raises in its letter.

Use of RF AGC to prevent interference to CPE. BeamReach wants to have it both ways. It references an earlier filed "analysis" of the potential for interference from satellite DARS repeaters in the Atlanta market. Predictably, BeamReach's study purported to find huge areas of potential interference, a conclusion that logically could flow only if BeamReach's study did not assume RF AGC in the WCS CPE. BeamReach Letter, pp. 1-2. Now, of course, BeamReach claims to have included RF AGC in its CPE design. If BeamReach has front-end RF AGC in its CPE, then the Atlanta results would differ dramatically, with any "potential for interference" virtually disappearing. The Commission should require BeamReach to update the record to reflect its new design. XM Radio has already demonstrated in its December 21st filing that front-end RF AGC would work to prevent interference to WCS CPE. *See* XM Radio *Ex Parte* Presentation, IB Docket 95-91 (Dec. 21, 2001).

Disparity in signal strength. BeamReach claims that it is impossible to use RF AGC to overcome what it says is 55 dB of disparity between its signal strength and that of a satellite radio repeater operating at 40 kW eirp. This claim completely ignores the fact that there is only 13 dB between 2 kW and 40 kW eirp, well within the range that can be accommodated through well-understood engineering techniques (including AGC). The additional 42 dB of margin that BeamReach seeks is the result of the defects in its own system design and implementation. That it may need to solve this problem by deploying additional base stations or increasing the power of its base stations is not the fault of the satellite radio licensees—the fault lies with BeamReach.

Use of filters to protect WCS base stations. Throughout this proceeding, BeamReach and the WCS licensees have claimed that higher power satellite radio repeaters will interfere with WCS base stations and that filters are too expensive to deploy to solve the alleged problem. *See, e.g.,* Ex Parte Letter from WCS Licensees, IB Docket 95-91 (Nov. 2, 2001), pp. 1-2; Ex Parte Letter from WCS Licensees, IB Docket No. 95-91 (Sept. 7, 2001), Technical Appendix pp. 1-2. Commission staff, as well as the satellite radio licensees, have expended significant resources addressing this claim and assessing possible solutions to rectify this problem. In its letter, BeamReach now reveals that it apparently already employs a filter that can withstand interference from higher power satellite radio repeaters. BeamReach Letter, p. 2. While it is not entirely clear from the letter, BeamReach apparently uses a duplex filter designed to limit interference into the satellite radio band consistent with Commission rules. This filter also is sufficient to withstand interference from satellite radio repeaters into the WCS bands.

Field tests in Houston with AT&T Wireless. BeamReach claims that XM Radio's testing in Houston of the effect of a higher power satellite radio repeater on AT&T Wireless's WCS CPE was "intentionally designed to yield the desired result." BeamReach Letter, p. 3. This statement ignores the fact that AT&T Wireless participated in the tests and certified the results. These results show conclusively that WCS consumer equipment can operate close to a higher power satellite radio repeater without experiencing overload—despite the predicted 11 mile wide exclusion zone.

XM Radio's March 5 analysis. BeamReach also wrongly criticizes XM Radio's analysis of WCS CPE performance with RF AGC. According to BeamReach, XM Radio's analysis understates the potential for interference caused by SDARS terrestrial repeaters by limiting the

measurements only to cases where the "SDARS Interfering Path Length" is always equal to or greater than "WCS Cell Size" (which would attenuate the "undesired" SDARS repeater signal somewhat). BeamReach Letter, p. 3. BeamReach is flatly wrong for two reasons. First, BeamReach misreads the study -- the XM Radio analysis assumed only that "SDARS Interfering Path Length" is always equal to or greater than "WCS Receiver Distance from the WCS Base Station," not the larger "WCS Cell Size." Second, XM Radio did not invent the parameters for its study that concluded that satellite DARS repeater would not interfere with WCS transceivers. Rather, XM Radio merely adopted assumptions about network geometry, path length, etc., identical to those used by the WCS licensees in their own analysis submitted last fall. *See* Ex Parte Letter from WCS Licensees, IB Docket 95-91 (Nov. 2, 2001), p. 16. The WCS and XM Radio studies, therefore, can be compared directly.

Cost of filters for CPE. BeamReach claims that filters for CPE to mitigate potential interference from SDARS repeaters will cost $70 each for CPE operating in the A and B bands and $2000 each for CPE operating in the C and D bands. BeamReach Letter, pp. 2-3. 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.

XM Radio's network and equipment. BeamReach claims that XM Radio's network is "over engineered" and that it can meet its 99.99% reliability target with 2 kW eirp repeaters. BeamReach Letter, p. 3 (citing Ex Parte Letter from BeamReach, et al., IB Docket No. 95-91 (Sept. 7, 2001)). As XM Radio has explained in the past, it has designed its network efficiently with as little power as possible to meet its 99.99% service availability requirement. *See* XM Radio *Ex Parte* Presentation, IB Docket 95-91 (Sept. 24, 2001), p. 13. The September 7th WCS filing uses modeling as a means to assess repeater coverage requirements. XM Radio, conversely, used real-world, drive test data to assess its coverage needs. While modeling may work for a provider of mobile data and telephony, it is not adequate for a broadcast service where consumers demand high quality service from a combination of satellite and terrestrial signal sources. In any event, as shown repeatedly on the record, the number of 2 kW terrestrial SDARS repeaters required to provide equivalent coverage is enormous and, apart from the very serious concerns of feasibility, service interruptions and cost, actually would *increase* the potential areas of interference to WCS as compared with the current networks. *See* XM Radio August 2001 White Paper, IB Docket 95-91 (Aug. 31, 2001), at 15-20; XM Radio *Ex Parte* Presentation, IB Docket 95-91 (Sept. 24, 2001), at 17-18.

DARS Consumer Antennae. BeamReach also claims that if XM Radio employs a different type of receiver antenna, it will be able to achieve its service reliability goals with 2 kW eirp repeaters. BeamReach Letter, p. 4. As an initial matter, XM Radio notes that customers have already purchased, and manufacturers have already produced, hundreds of thousands of the low gain monopole antennas BeamReach would like to replace. Requiring consumers to replace these antennas and manufacturers to cease production would come at a huge cost. Moreover, BeamReach is simply wrong in its characterization of XM Radio's antenna as having a peak gain of -5 dbi at the horizon. In fact, as described in published specifications for the equipment, the

peak gain at the horizon is -1 dBi. The consumer antenna offered by Sirius has nearly identical characteristics. The addition of 10 dbi to compensate for lower power repeaters would require both DARS licenses' antennae to be well over a foot high, which would be completely unacceptable to car manufacturers and the average consumer.

Please direct any questions regarding this matter to the undersigned.

Very truly yours,

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Filters for WCS Receivers

White Paper

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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.

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 objectional.

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.

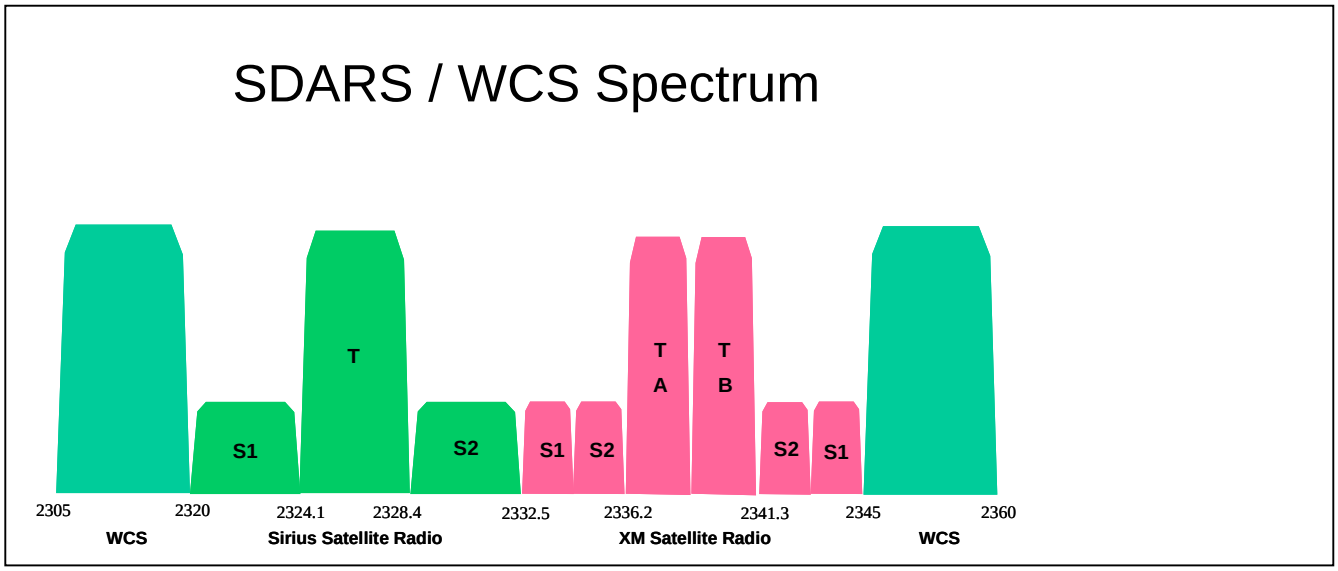

Figure 1. SDARS/WCS Spectrum showing frequency distribution. (Note that the frequency axis is non-linear with the SDARS bands emphasized.)

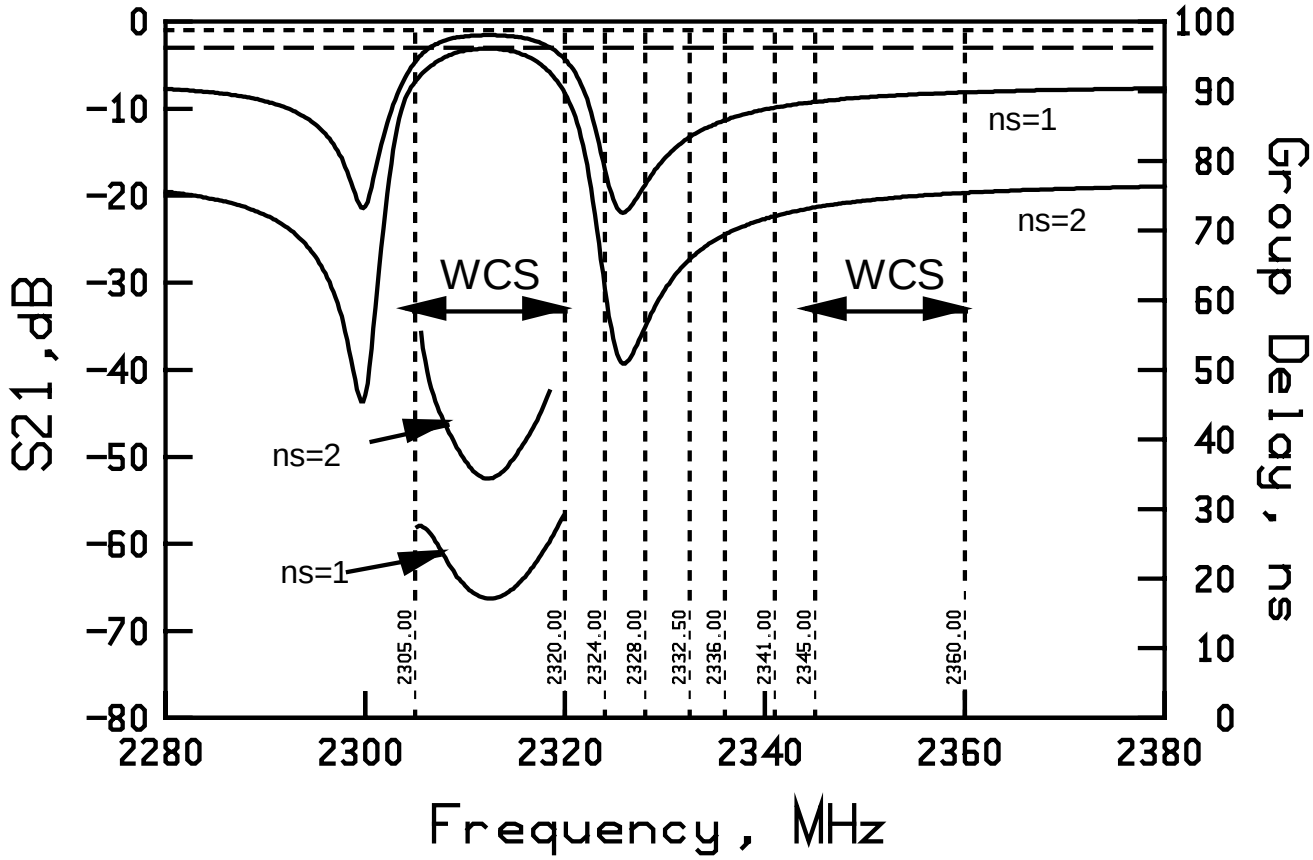

Figure 2. Simulation of receiver filter responses for the lower WCS band, showing design tradeoffs. The “ns” denotes the number of T network sections in the crystal ladder filter.

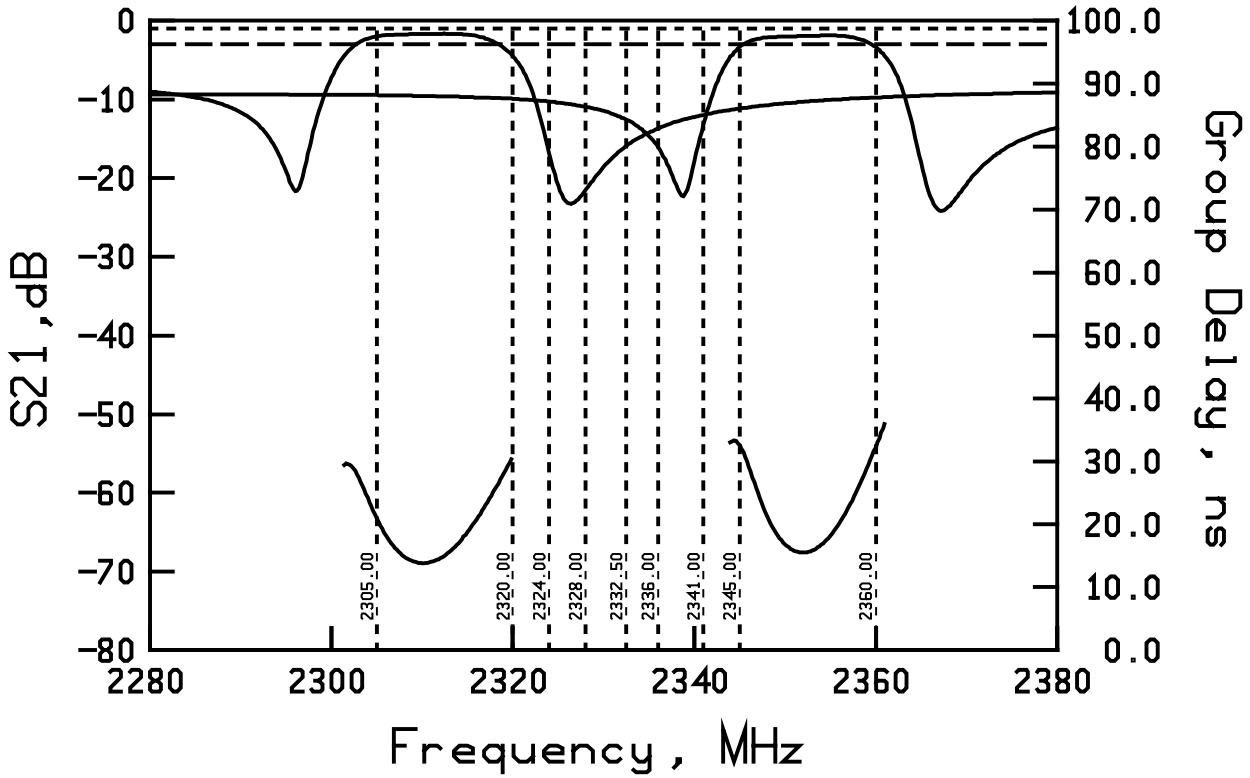

Figure 3. Two WCS filters having slightly wider passbands than those in Fig. 2.

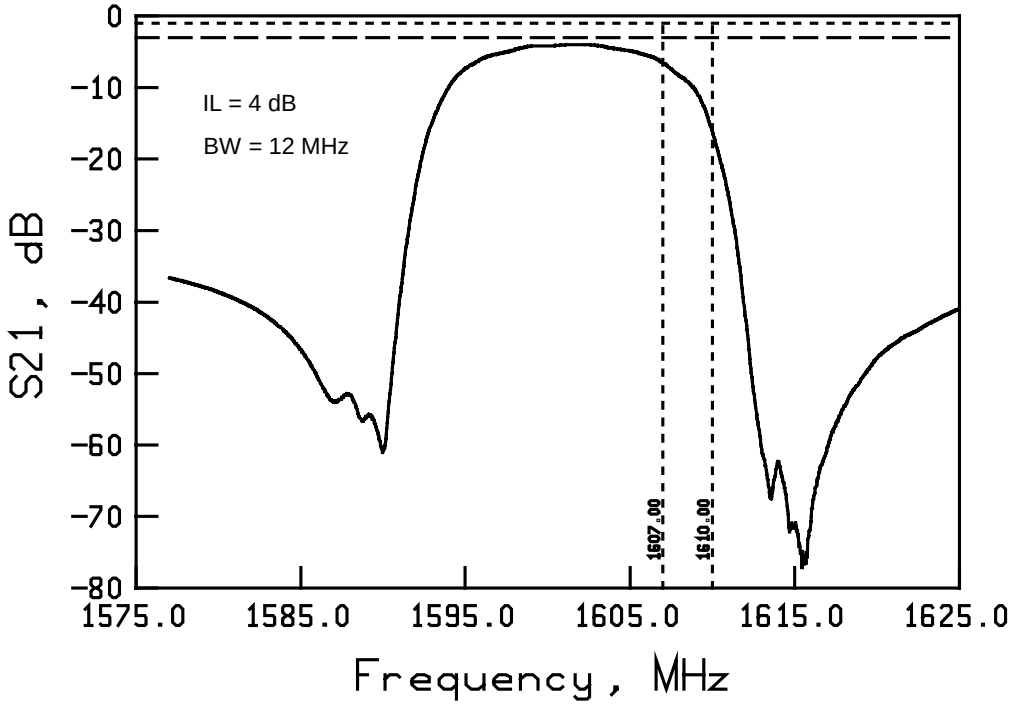

Figure 4. Production filter, made by TFR Technologies, used in an aircraft navigation system, to protect the receiver from close proximity SATCOM transmitters.

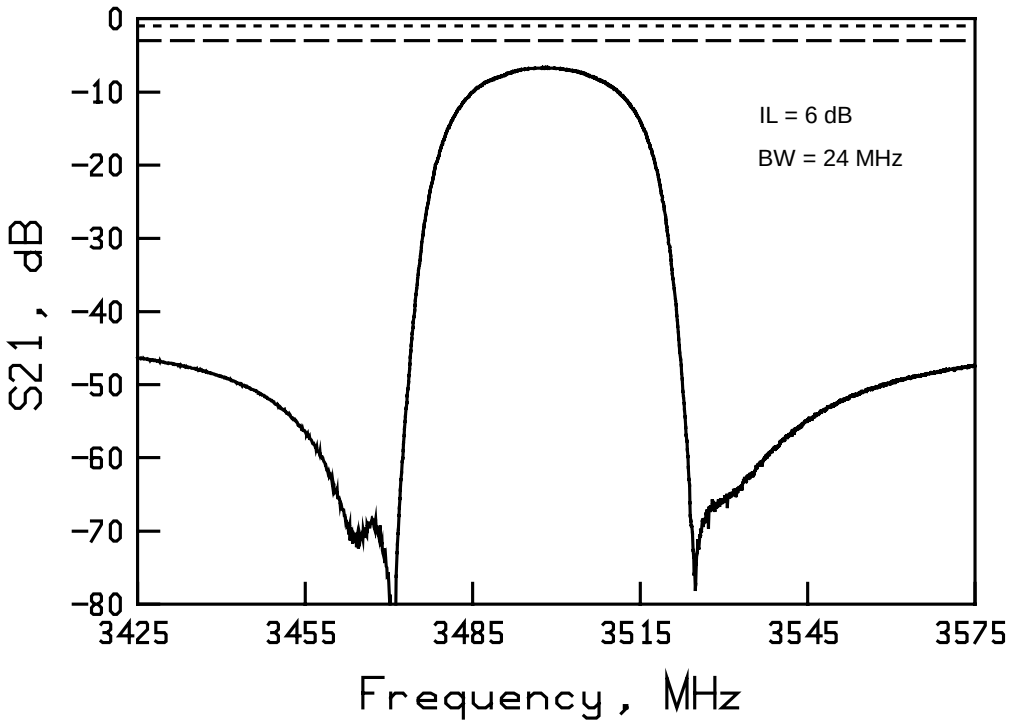

Figure 5. Production narrow bandwidth high skirt selectivity filter illustrating tradeoffs between out-of-band rejection, in-band insertion loss, and loss of signal at corner frequencies.

Reference:

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

Deployment of TFR Filter

The TFR filter is intended for deployment after the first high linearity gain stage in the receiver. With this implementation, the receiver sensitivity is not degraded while the gain and mixer stages after the filter are protected from intermodulation and overload from high level SDARS signals.

The recommended configuration for FDD systems is shown in Figure 1 below.

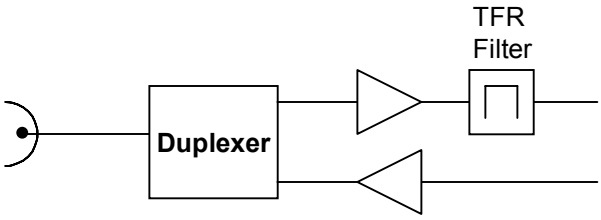

Figure 1. Filter Deployment in FDD System

The recommended configuration for TDD systems is shown in Figure 2 below.

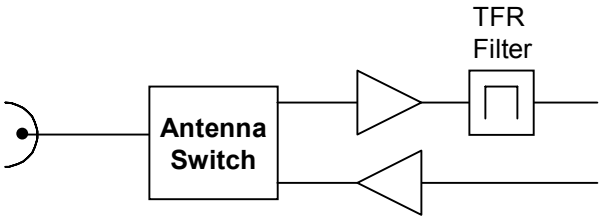

Figure 2. Filter Deployment in TDD System

QUOTATION

TFR TECHNOLOGIES, Inc.
63140 Britta St., Suite C-106
Bend, OR 97701
Ph: (541) 382-6706
Fx: (541) 382-7783

DATE: **March 26, 2002**

Unless otherwise specified,
Quote is valid for 90 days.

Customer:
Paul Marko
XM Satellite Radio, Inc.
Ph: 561-226-1219
Fx: 561-883-5642

PREPARED BY:	QUOTATION No.
Jeff McDonald	XMR-247

ITEM#	QTY	DESCRIPTION	PER UNIT	AMOUNT
1		Single or Two Pole WCS Filter		
		Performance shown on attached simulation		
		Filter Package to be smallest obtainable:		
		(Either 0603 or 1206-size package)		
		NRE		$4,000.00
		Wafer Run Charge		$4,000.00
	1 to 50	Tested and Packaged Filters (at cost)	$25.00	
		NOTE:		
		This work will be performed on a "best		
		effort basis" by TFR.		
		TERMS: Net 30 days		
		LEAD-TIME: 12 weeks ARO		

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