Table 1

INTRODUCTION

The following is an interference analysis of a potential fixed wireless application at 2305-2320 MHz and 2345-2360 MHz into the Satellite Digital Audio Radio System.

APPROACH

The interference analysis is based on an approach similar to that used by Primosphere Limited Partnership. However, we feel that several of the assumptions made by Primosphere are overly conservative, and therefore have proposed different assumption based on our experience.

The SDARS receiver system noise energy is first computed based on a reasonably good receiver design. Allowing for a couple of dB of fluctuation, an allowable interference noise energy is established. Further, based on the EIRP of a typical Fixed Wireless System (FWS), the path loss stemmed from the distance between the SDARS antenna and the FWS antenna, and the FWS antenna pattern gain roll-off, the link budget is computed. Thus the isolation required is determined and compared to the FCC proposed isolation requirement.

INTERFERENCE ANALYSIS

Without an expensive sophisticated cooling mechanism, the Noise Temperature for any receiver RF front end must exceed the ambient Thermal Noise Temperature of 290 °K. Assuming the SDARS receiver has a reasonably good LNA and with the Receiver RF front end Noise Figure accounted for, it is rather realistic to assume a 2,000. °K of SDARS Noise Temperature, which translates to 33 dBK.

Thus, the SDARS system Noise Energy = -228.6 dBW/K-Hz +33 dBK
or -135.6 dBW/MHz.
or -2.754 E-14 W/MHz.

In order to allow for a 2 dB increase on the Interference Noise Energy budget for an average SDARS receiving system, -133.6 dBW/MHz (or 4.365 E-14 W/MHz) is allowed. This results in a delta of 1.611E-14 W/MHz or -137.9 dBW/MHz Allowed Interference Noise Energy.

FWS Forward Link

Consider the Forward Link of a typical Fixed Wireless System. The EIRP from the Base Station (BS) is typically 16 dBW/MHz. Based on the directional antenna pattern look angles and distances, 3 cases are examined here.

Case 1. Assume that the SDARS antenna is approximately 100 ft from the base of the BS antenna tower where the BS antenna is mounted 100 ft above ground. The distance D_s used for path loss calculation is

D_s = 141.4 ft, assuming SDARS antenna is on the ground.

Assuming free space, the path loss, $L_s = 10 \log (4 \pi D_s / \lambda)^2$,

where λ = 0.4203 ft, the wavelength at 2340 MHz,

L_s = -72.5 dB.

Even if the BS antenna is tilted down as much as 5 degrees towards the ground and, at such a close distance, the SDARS antenna is at a directional angle outside of the first sidelobe region. Based on the BS antenna pattern, the gain at such look angle is more than 20 dB below that of the main beam peak. The Fixed Wireless system interference to SDARS is determined as follows:

BS EIRP		16 dBW/MHz
Minimum path loss		-72.5 dB
Minimum BS antenna pattern roll-off		-20.0 dB
SDARS antenna gain	+	3.0 dB
Interfering energy from FWS at SDARS receiver		-73.5 dBW/MHz
Interference Noise Energy Allowed		-137.9 dBW/MHz
Required Out-of-band Isolation		-63.4 dB

Comparing this number to the -70 dB Out-of-band Emission proposed by FCC, this worst-case analysis meets the proposed FCC specification with at least 6.6 dB to spare. This is a rather conservative number considering there are other additional losses such as cable loss and antenna polarization loss etc. which would amount to additional 4 dB of additional margin and thus relax the out-of band emission requirement to 60+10log(p).

Case 2, let's double the distance between the SDARS antenna and the base of the BS antenna tower. D_s = 223.6 ft, and thus L_s = -76.5 dB. The directional angle is such that the SDARS appears outside of the BS antenna main lobe region where the energy received will be at least 18 dB below that from the BS antenna main beam peak. The gain reduction could be even greater at the region between the main lobe and the first sidelobe. Similarly, the Fixed Wireless system interference to SDARS is determined as follows:

BS EIRP		16 dBW/MHz
Minimum path loss		-76.5 dB
Minimum BS antenna pattern roll-off		-18.0 dB
SDARS antenna gain	+	3.0 dB
Interfering energy from FWS at SDARS receiver		-75.5 dBW/MHz
Interference Noise Energy Allowed		-137.9 dBW/MHz
Required Out-of-band Isolation		-62.4 dB

Comparing this number to the 70 dB isolation proposed by FCC, this worst-case analysis meets the proposed FCC specification with more than 7.6 dB to spare. Similarly, by adding the possible cable loss and antenna polarization loss etc., additional 4 dB of margin is realized and thus the out-of band emission requirement of 60+10log(p) is more than adequate here.

Case 3, Assume that the BS antenna is not down tilted. In order for the SDARS antenna to be seen at the FWS BS antenna near main beam region, the distance would be at least 1370 ft. That is when the SDARS antenna is in the direction with pattern roll-off of 2dB below BS antenna main beam peak. Thus, D_s = 1373ft, and thus L_s = -92.3 dB. Again, the Fixed Wireless system interference to SDARS is determined as follows:

BS EIRP		16 dBW/MHz
Minimum path loss		-92.3 dB
BS antenna pattern roll-off		-2.0 dB
BS antenna pattern roll-off		-2.0 dB
SDARS antenna gain	+	3.0 dB
Interfering energy from FWS at SDARS receiver		-73.5 dBW/MHz
Interference Noise Energy Allowed		-137.9 dBW/MHz
Required Out-of-band Isolation		-64.4 dB

Comparing this number to the -70 dB isolation proposed by FCC, there is a 5.6 dB of margin in case. However, with additional cable loss and antenna polarization loss accounted for, the isolation required is well within the 60dB region. Again, one should be convinced that 60+10log(p) is sufficient.

FWS EIRP		10 dBW/MHz
Path loss at 100ft		-69.2 dB
BS antenna pattern roll-off		0.0 dB
SDARS antenna gain	+	3.0 dB
Interfering energy from FWS at SDARS receiver		-56.2 dBW/MHz
Interference Noise Energy Allowed		-158.6 dBW/MHz
Required Out-of-band Isolation		-102.4 dB

Comparing this number to the 70 dB isolation proposed by FCC, Primosphere suggested that an additional isolation of 32.4 dB should be required. Based on their assumptions, a -89.4dB (or approximately -90 dB) Out-of-band emission is proposed by Primosphere. Lucent Technologies believes this is too conservative as expressed above.

FWS Reverse Link

Let's now consider the Reverse Link of a typical Fixed Wireless System. The EIRP from the Subscriber Station (SS) is nominally 8dBW/2.5MHz, or 4 dBW/MHz. Due to the highly directive nature of the SS antenna, the back lobe is well below 25 dB with respect to the main beam peak. Assuming the SDARS antenna is about 100 ft from the SS antenna, the path loss is computed to be -59.5 dB. The Fixed Wireless system interference to SDARS is determined as follows:

SS EIRP		4 dBW/MHz
Path loss		-69.5 dB
Pattern roll-off		-25.0 dB
SDARS antenna gain	+	3.0 dB
Interfering energy from FWS at SDARS receiver		-87.5dBW/MHz
Interference Noise Energy Allowed		-137.9 dBW/MHz
Required Out-of-band Isolation		-50.4 dB

Comparing this number to the 70 dB isolation proposed by FCC, this meets the proposed FCC specification with almost 20 dB to spare without even accounting for other additional losses. Similar to the above analysis for the forward link, by adding the possible cable loss and antenna polarization loss etc., additional 4 dB of margin is realized and thus the out-of band emission requirement of 50+10log(p) is more than adequate here.

Comparison to Primosphere Interference Analysis

According to the response letter from Primosphere to FCC, the SDARS receiver Noise Temperature was assumed to be 200.0 °K. This resulted in a system Noise Energy of -145.6 dBW/MHz, which yielded a good 10 dB more conservative number than that of a practical receiving system.

The allowable 0.2 dB increase in Noise Energy is almost un-measurable because an average spectrum analyzer has resolution of 0.1dB. We believe a more reasonable assumption would be 2 dB, and have used that in the above computation.

Primosphere assumed a 10 dBW/MHz of FWS EIRP, without accounting for any pattern roll-off due to a high directivity antenna typically used for the Fixed Wireless systems and/or other mis-match VSWR gain drop or antenna polarization gain drop. The link budget is summarized below: