FM HD Radio™

Field Performance

With

Unequal Digital Sideband Carrier Levels

(Preliminary)

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Table of Contents

1 TEST DESCRIPTION 3
2 OPERATING POWER 3
3 TRANSMITTER TEST SITE 4
4 TRANSMISSION FACILITY INFORMATION 4
5 RADIATION PARAMETERS 4
6 ANTENNA 4
7 ANTENNA CONFIGURATION 4
8 WKLB ASYMMETRIC SIDEBAND TEST ROUTES AND INTERFERERS 6

Figures

FIGURE 1. DUAL INPUT ANTENNA 4
FIGURE 2. WKLB ASYMMETRIC SIDEBAND OPERATING POWER 5
FIGURE 3. WKLB TEST ROUTES 6
FIGURE 4. NORTH ROUTE, DRIVING AWAY – SYMMETRIC VS. ASYMMETRIC, DIFFERENT TOTAL DIGITAL POWER 7
FIGURE 5. NORTH ROUTE, DRIVING AWAY – SYMMETRIC VS. ASYMMETRIC, SAME TOTAL DIGITAL POWER 8
FIGURE 6. NORTH ROUTE, DRIVING AWAY – DIFFERENT ASYMMETRIC CASES, DIFFERENT TOTAL DIGITAL POWER 9
FIGURE 7. NORTH ROUTE, DRIVING TOWARDS – SYMMETRIC VS. ASYMMETRIC, DIFFERENT TOTAL DIGITAL POWER 10
FIGURE 8. NORTH ROUTE, DRIVING TOWARDS – SYMMETRIC VS. ASYMMETRIC, SAME TOTAL DIGITAL POWER 11
FIGURE 9. NORTH ROUTE, DRIVING TOWARDS – DIFFERENT ASYMMETRIC CASES, DIFFERENT TOTAL DIGITAL POWER 12
FIGURE 10. SOUTH ROUTE, DRIVING AWAY – SYMMETRIC SIDEBANDS 13
FIGURE 11. SOUTH ROUTE, DRIVING AWAY – ASYMMETRIC SIDEBANDS 14
FIGURE 12. SOUTH ROUTE, DRIVING AWAY – ASYMMETRIC SIDEBANDS, TOTAL POWER EQUIVALENT TO SYMMETRIC 15
FIGURE 13. SOUTH ROUTE, DRIVING TOWARDS – SYMMETRIC SIDEBANDS 16
FIGURE 14. SOUTH ROUTE, DRIVING TOWARDS – ASYMMETRIC SIDEBANDS 17
FIGURE 15. SOUTH ROUTE, DRIVING TOWARDS – ASYMMETRIC SIDEBANDS, TOTAL POWER EQUIVALENT TO SYMMETRIC 18

1 Test Description

These tests characterize the digital coverage improvement that may be realized by a typical FM Class B broadcaster using asymmetric IBOC transmission power. This method affords the broadcaster the ability to mitigate potential first-adjacent digital-to-analog interference by allowing independent adjustment of upper and lower IBOC digital sideband levels.

With the help of funding from NAB FASTROAD and technical support from Greater Media, iBiquity was able to conduct digital signal reception performance field testing in the Boston market to characterize the digital coverage improvement that an increase in power of a single IBOC digital sideband can achieve.

In past test efforts, which almost exclusively involved symmetric sideband operation, the total, combined, integrated power of both the IBOC digital sidebands (in a 70-kHz bandwidth) was used to describe the digital power in the signal (compared against the power of the analog carrier, in units of dBc). In order to properly characterize the digital carrier power in an asymmetric implementation, the power of each digital sideband must be stated separately. In this case, the convention is to express the power of each digital sideband in the dBc equivalent to the *total* power in the equal sideband case, which can lead to confusion.

Using this convention, an asymmetric power profile of "-10 dBc / -14 dBc" describes the situation where the upper sideband is at the symmetric total power equivalent of -10 dBc and the lower sideband is at the symmetric total power equivalent of -14 dBc. Note that the power in each of these sidebands is actually -13 dBc / -17 dBc since the power of individual sidebands (in the symmetric case) is 3 dB less than the total power. It is important to keep this in mind when reading this report and the values in Table 1 are denoted in this manner.

2 Operating Power

For these tests, WKLB operated at various total digital power levels from 14 dB to 10 dB below that of the reference analog carrier (that is, -14 dBc to -10 dBc). The digital-to-analog power ratio was verified by using a power meter to measure the digital sideband power; then transmission system loss and antenna gain calculations supplied by the equipment manufacturers were used to establish the power ratio.

The Exgine Exciter used in these tests only had the functionality of making asymmetric power adjustments in 1 dB increments, and the desired digital subcarrier profile for the two asymmetric sideband runs conducted during these tests was set to a differential power of 4 dB. The upper IBOC digital sideband power was not allowed to exceed -17 dBc (total digital power equivalent of -14 dBc), pursuant to WKLB's experimental FCC authorization, and was held at a constant power of -17 dBc (± 0.1 dB / 2.3% power), monitored using the channel power function on a spectrum analyzer.

With the upper digital sideband power held to a constant -17 dBc, the measured lower digital sideband channel power was -13.75 dBc and not the target -13 dBc (total digital power equivalent of -10 dBc), probably due to power amplifier compression. Since 5 dB of asymmetry (the next increment) would have put the lower sideband above its maximum authorized level of -13 dBc (at -12.75 dBc), we were compelled to run conservatively with 3.25 dB of asymmetry as opposed to the target of 4 dB.

Table 1 and the spectrum analyzer plot shown in Figure 2 characterize the three operating powers for these tests.

3 Transmitter Test Site

These tests were conducted using the RF transmission facilities of WKLB, Waltham, MA (Boston). WKLB was granted experimental authority under FCC 47 CFR 73.1510 (d) to operate with digital power levels up to and including -13 dBc (-10 dBc total digital power equivalent) on the lower IBOC sideband and no more than -17 dBc (-14 dBc total digital power equivalent) on the upper IBOC sideband.

4 Transmission Facility Information

FCC Facility ID: 10542
North latitude 42° 18’ 37”
West longitude 71° 14’ 14”
Asymmetric high-power IBOC authority per 47 CFR 73.1510 (d) granted 8/27/10 and expiring on 2/28/11

5 Radiation Parameters

AGL	290 m	
G AMSL	30 m	
RC AMSL	320 m	
HAAT	272.27 m	
ERP (analog)	14.0 kW	
Symmetric operation TPO (digital)	655 W	(-16.21 dBc / -16.21 dBc – mode MP3)
4 dB asymmetric opération TPO (digital)	1277.1 W	(-12.21 dBc / -16.21 dBc – mode MP3)
3.25 dB asymmetric operation TPO (digital)	1136 W	(-12.96 dBc / -16.21 dBc – mode MP3)

6 Antenna

ERI Model 1183-4CP-2 dual-input hybrid IBOC

7 Antenna Configuration

WKLB uses an ERI Model 1183-4CP-2 dual-input hybrid IBOC panel antenna: the configuration is shown in Figure 1.

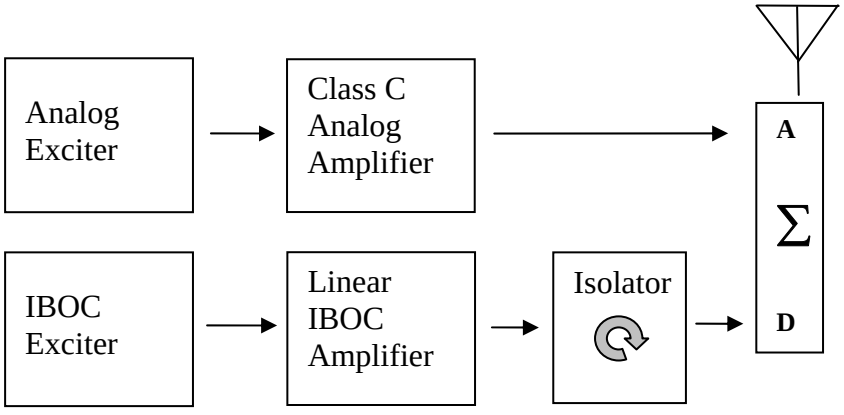


Figure 1. Dual Input Antenna

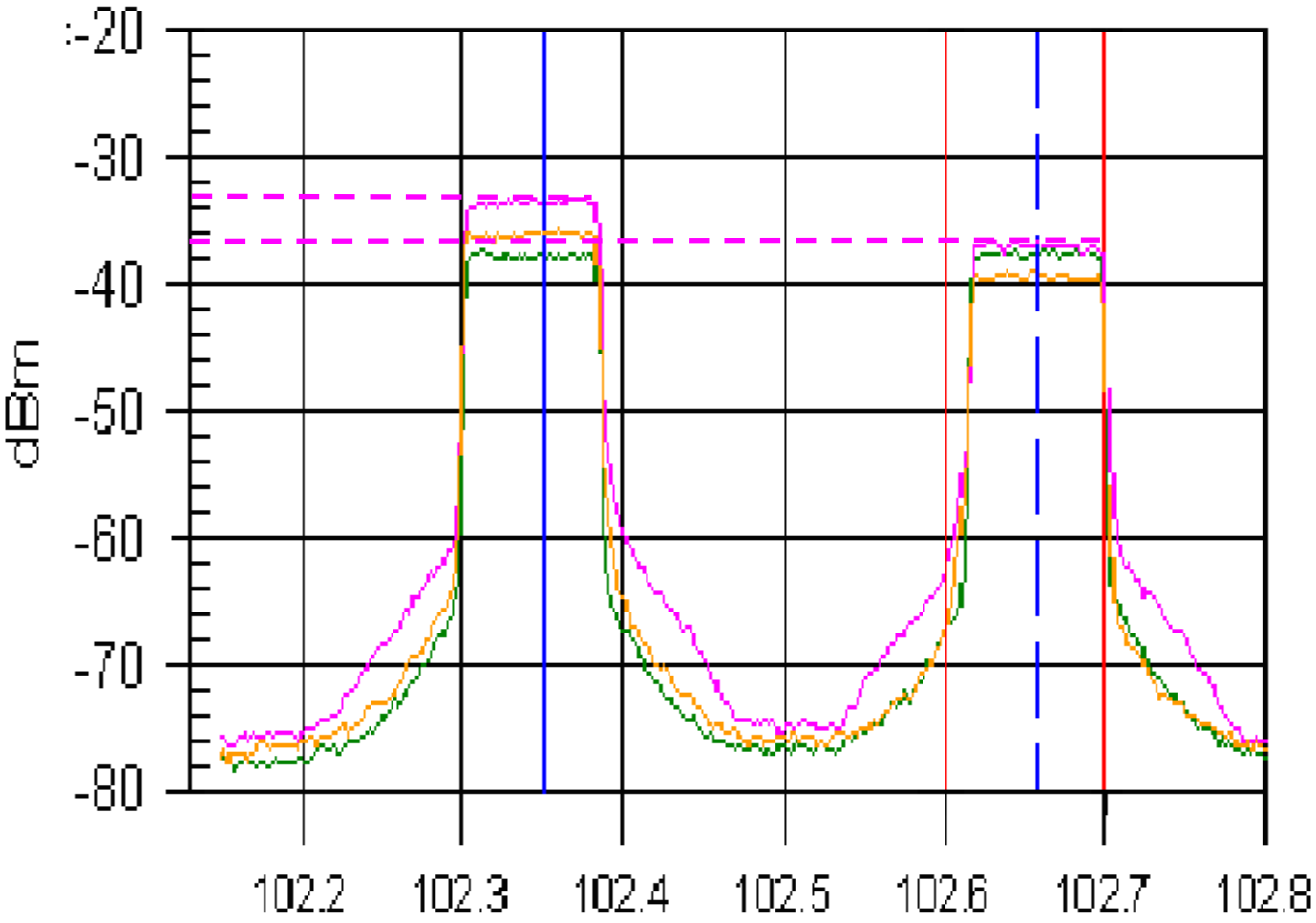


Figure 2. WKLB Asymmetric Sideband Operating Power

D/A Ratio (dBc) LSB / USB	Wattmeter Total Power (watts)	Raw Channel Power (from Analyzer)		
		LSB (dBm)	USB (dBm)	LSB – USB (dB)
-17 / -17	655	-18.21	-18.25	0.04
-13 / -17	1136	-14.93	-18.18	3.25
-15.15 / -18.4	655	-17.49	-20.60	3.11

Table 1. WKLB Operating Power

8 WKLB Asymmetric Sideband Test Routes and Interferers

Two routes, previously used for WKLB symmetric high-power testing, were run for these tests (shown in Figure 3). The South Route, on I-95, begins just south of the intersection with I-495 and continues through Pawtucket and Providence, RI, finally ending at Route 3, South of West Warwick, RI. This route proved to be a good test of coverage at various digital transmission power levels. The North Route begins at I-495 and follows I-93 North through Derry, Manchester and Hooksett, NH.

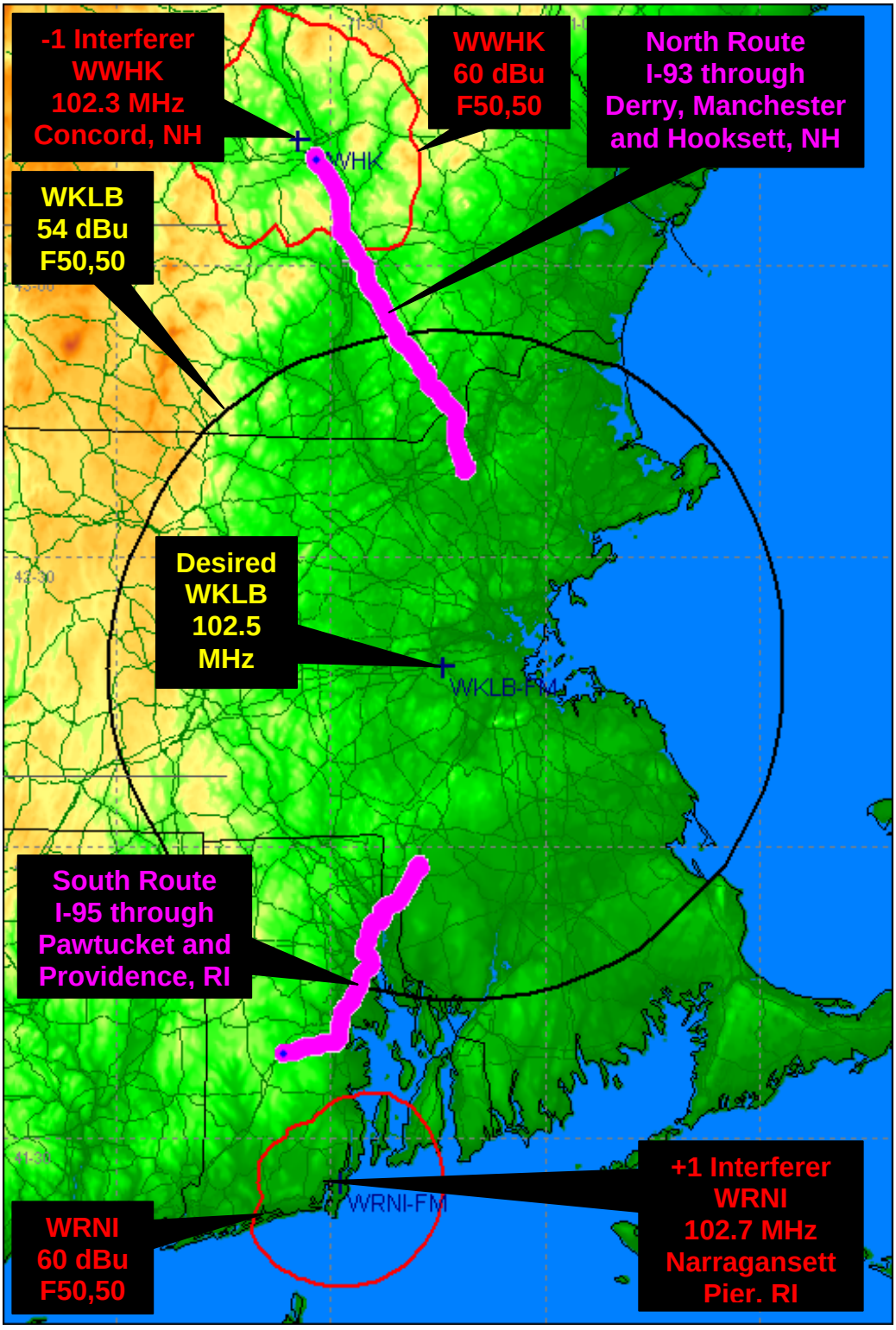
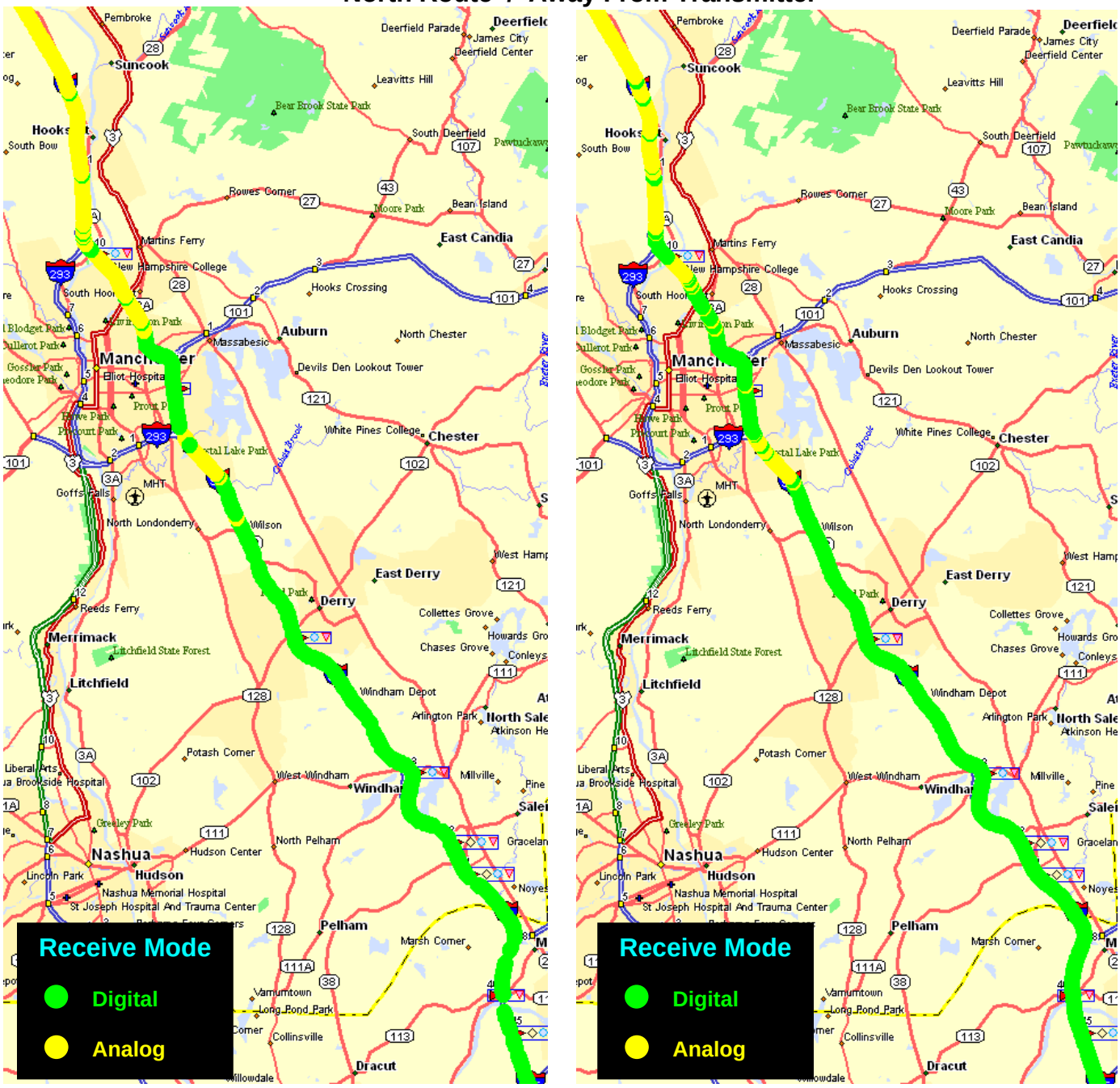


Figure 3. WKLB Test Routes

North Route / Away From Transmitter

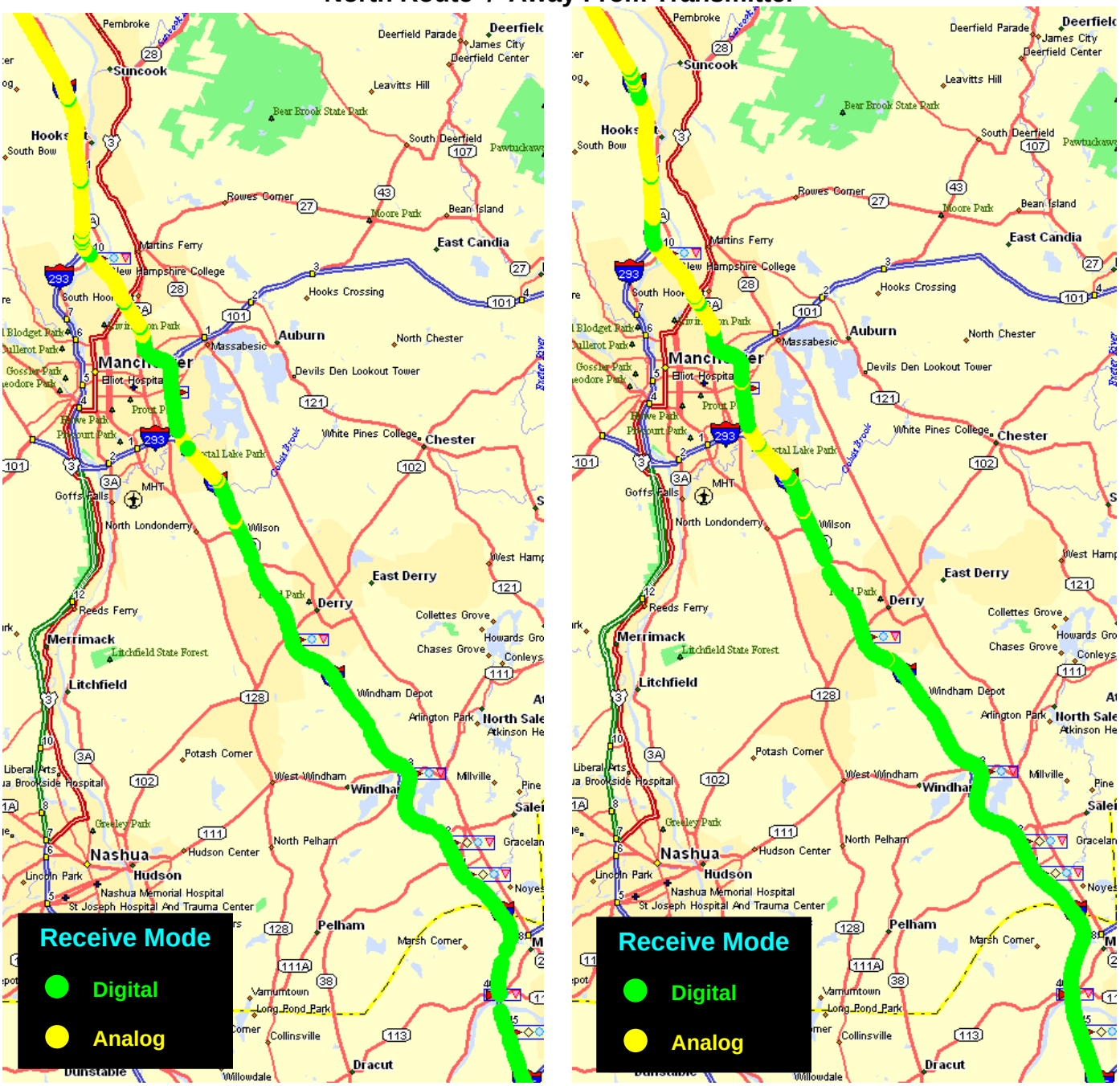


a) At left: WKLB @ -17 dBc / -17 dBc (-14 dBc total)
b) At right: WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)

Figure 4. North Route, driving away – symmetric vs. asymmetric, different total digital power

The maps in Figure 4 compare coverage when driving away from the WKLB transmitter with the upper sideband power held constant at -17 dBc and the lower sideband power raised by 3.25 dB to -13.75 dBc, for a total power of -12.1 dBc. Note that the robustness of the lower sideband is compromised by a lower first-adjacent interferer: WWHK Concord, New Hampshire.

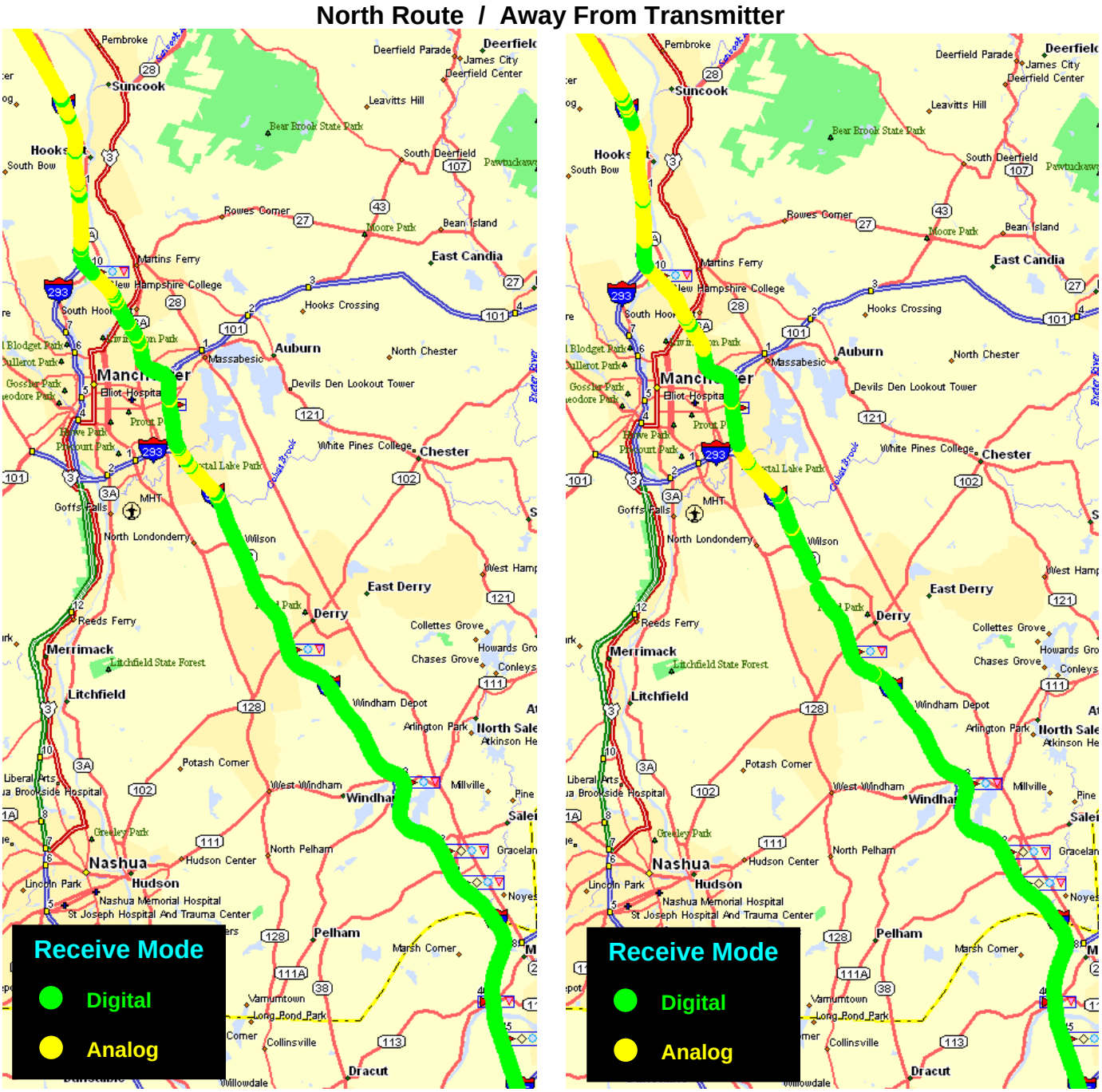
North Route / Away From Transmitter



a) At left: WKLB @ -17 dBc / -17 dBc (-14 dBc total)
b) At right: WKLB @ -15.65 dBc / -18.9 dBc (-14 dBc total)

Figure 5. North Route, driving away – symmetric vs. asymmetric, same total digital power

The maps in Figure 5 compare 3.25-dB offset asymmetric coverage to the same 655-watt / -14-dBc total power as the symmetric -17 dBc / -17 dBc (or -14-dBc total power) runs. The lower sideband power is set at -15.65 dB and the upper sideband power is set at -18.9 dB, for a total power of -14 dBc. Note that the robustness of the lower sideband is compromised by a lower first-adjacent interferer: WWHK Concord, New Hampshire.

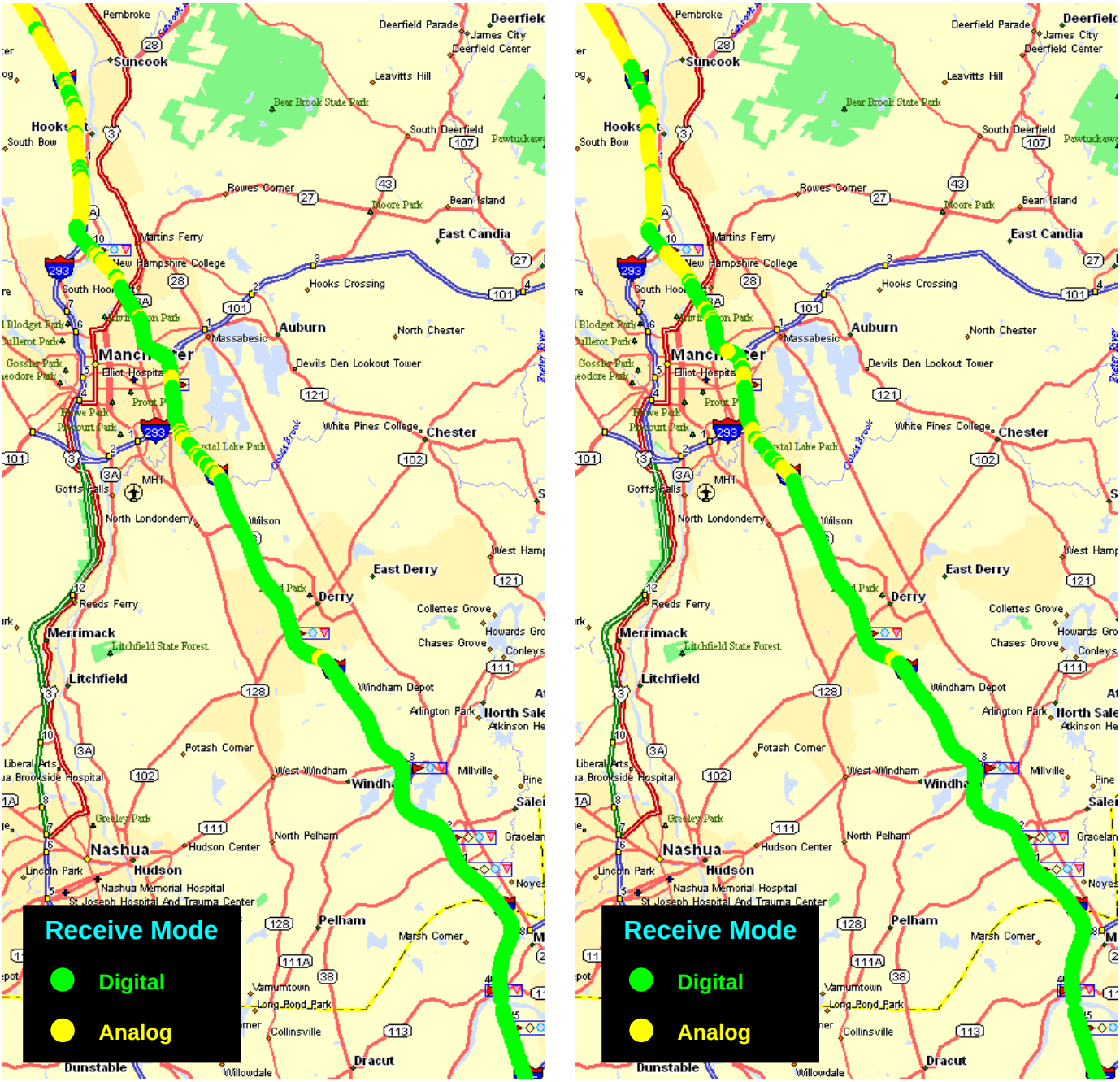


a) At left: WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)
b) At right: WKLB @ -15.65 dBc / -18.9 dBc (-14 dBc total)

Figure 6. North Route, driving away – different asymmetric cases, different total digital power

Figure 6 shows the same route comparing two asymmetric (by 3.25 dB) power levels. The left map has the lower sideband at the -13.75 dBc level and the upper sideband at the -17 dBc level, for a total power of -12.1 dBc. On the right map, the power in each digital sideband was reduced by the same amount (1.9 dB) so as to achieve the same total power level as the symmetric -17 dBc / -17 dBc (i.e., -14 dBc total power) case.

North Route / Toward Transmitter

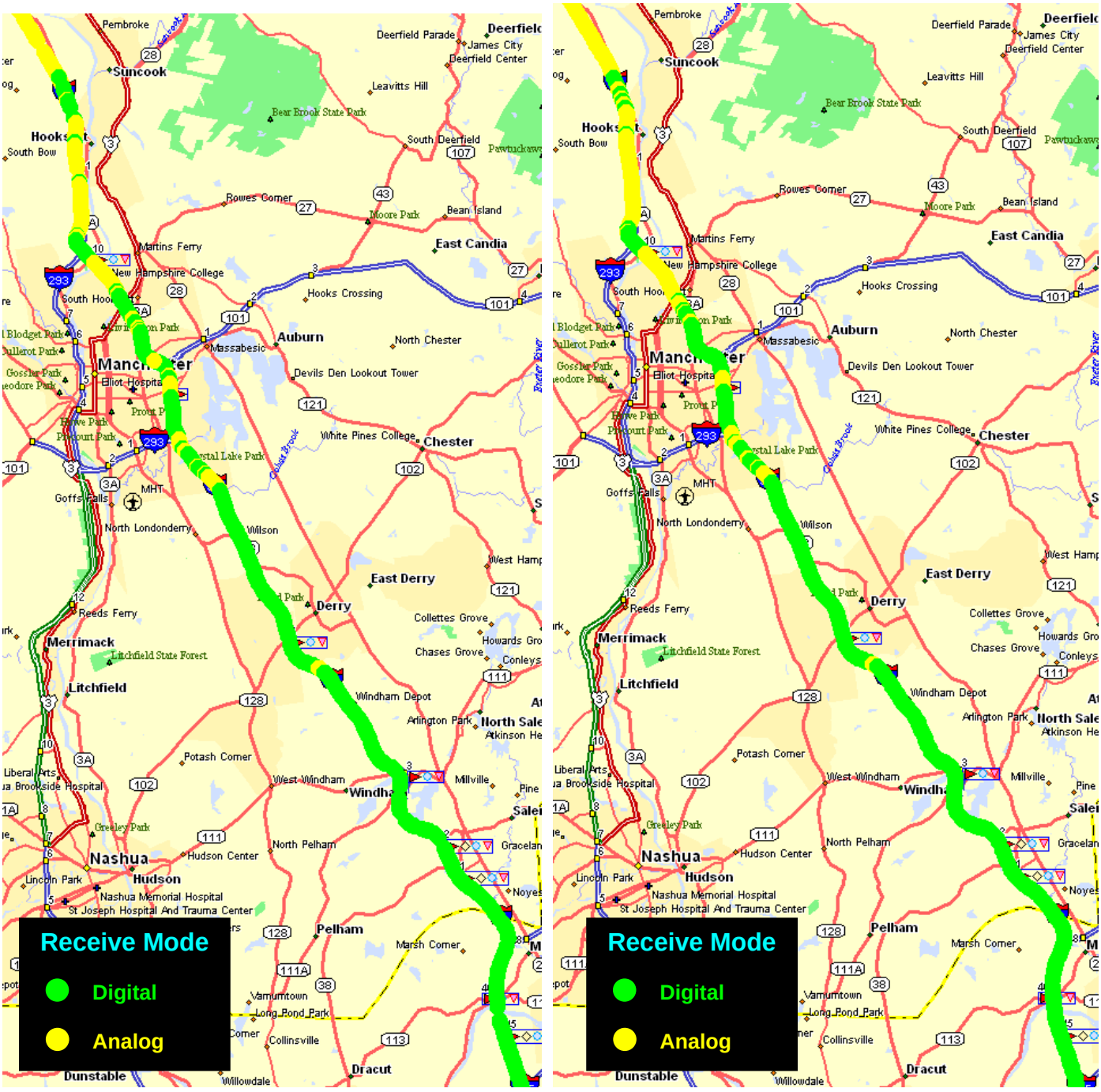


a) At left: WKLB @ -17 dBc / -17 dBc (-14 dBc total)
b) At right: WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)

Figure 7. North Route, driving towards – symmetric vs. asymmetric, different total digital power

The maps in Figure 7 compare coverage when driving toward the WKLB transmitter with the upper sideband power held constant at -17 dBc and the lower sideband power raised by 3.25 dB to -13.75 dBc, for a total power of -12.1 dBc. Note that the robustness of the lower sideband is compromised by a lower first-adjacent interferer: WWHK Concord, New Hampshire. (Compare these results to those in Figure 4: the situation is the same except for the fact that the driving direction is away from the WKLB transmitter in Figure 4.)

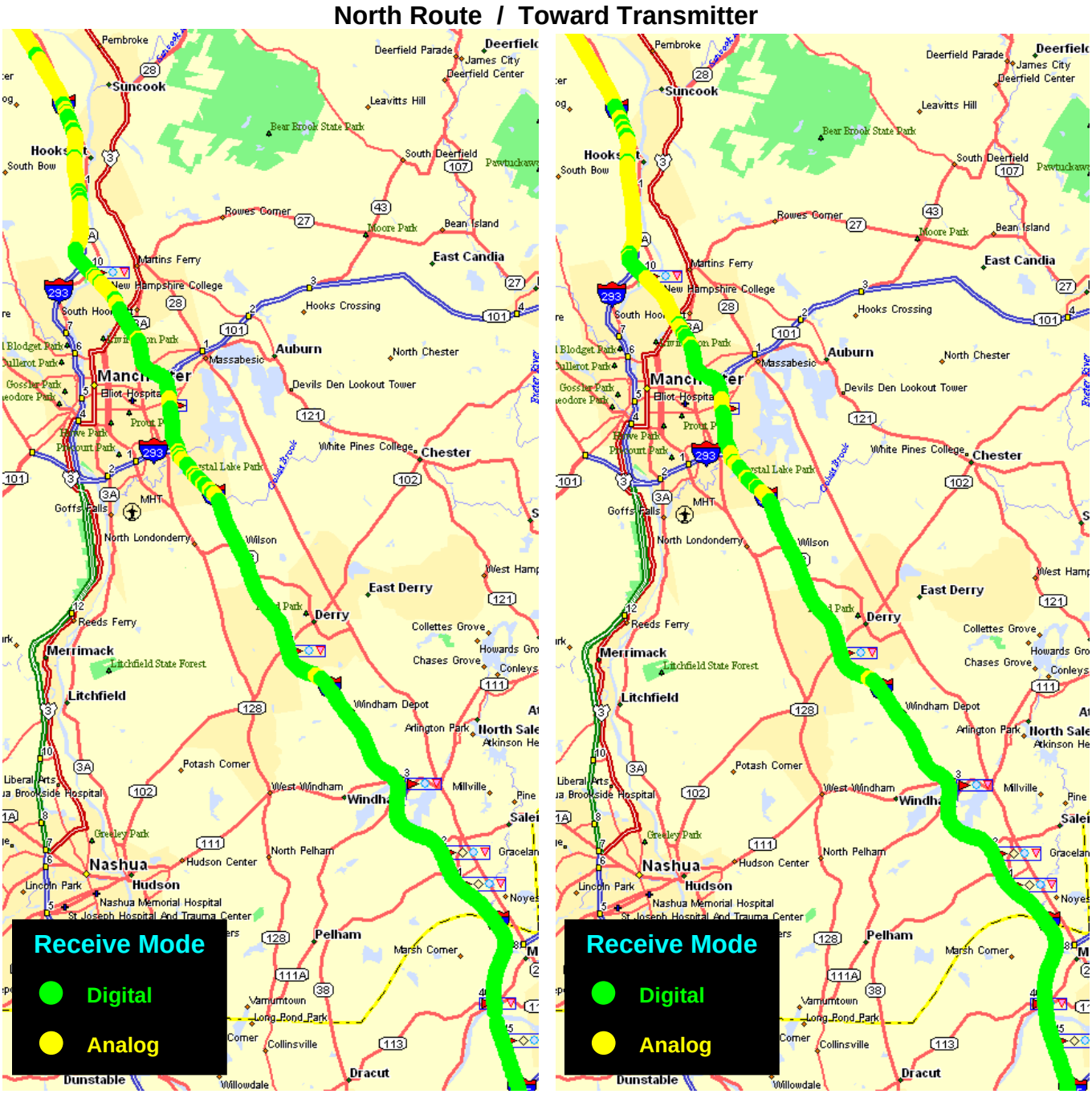
North Route / Toward Transmitter



a) At left: WKLB @ -17 dBc / -17 dBc (-14 dBc total)
b) At right: WKLB @ -15.65 dBc / -18.9 dBc (-14 dBc total)

Figure 8. North Route, driving towards – symmetric vs. asymmetric, same total digital power

The maps in Figure 8 compare 3.25-dB offset asymmetric coverage to the same 655-watt total power of the symmetric -17 dBc / -17 dBc (or -14-dBc total power) runs. The lower sideband power is set at -15.65 dB and the upper sideband power is set at -18.9 dB. Note that the robustness of the lower sideband is compromised by a lower first-adjacent interferer: WWHK Concord, New Hampshire. (Compare these results to those in Figure 5: the situation is the same except for the fact that the driving direction is away from the WKLB transmitter in Figure 5.)



a) At left: WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)
b) At right: WKLB @ -15.65 dBc / -18.9 dBc (-14 dBc total)

Figure 9. North Route, driving towards – different asymmetric cases, different total digital power

Figure 9 shows the same route comparing two asymmetric (by 3.25 dB) power levels, driving toward the transmitter. The left map has the lower sideband at the -13.75-dBc level and the upper sideband at the -17-dBc level, for a total power of -12.1 dBc. On the right map, the power in each digital sideband was reduced the same amount (1.9 dB) so as to achieve the same total power level as the symmetric -17 dBc / -17 dBc (i.e., -14-dBc total power) case. (Compare these results to those in Figure 6: the situation is the same except for the fact that the driving direction is away from the WKLB transmitter in Figure 6.)

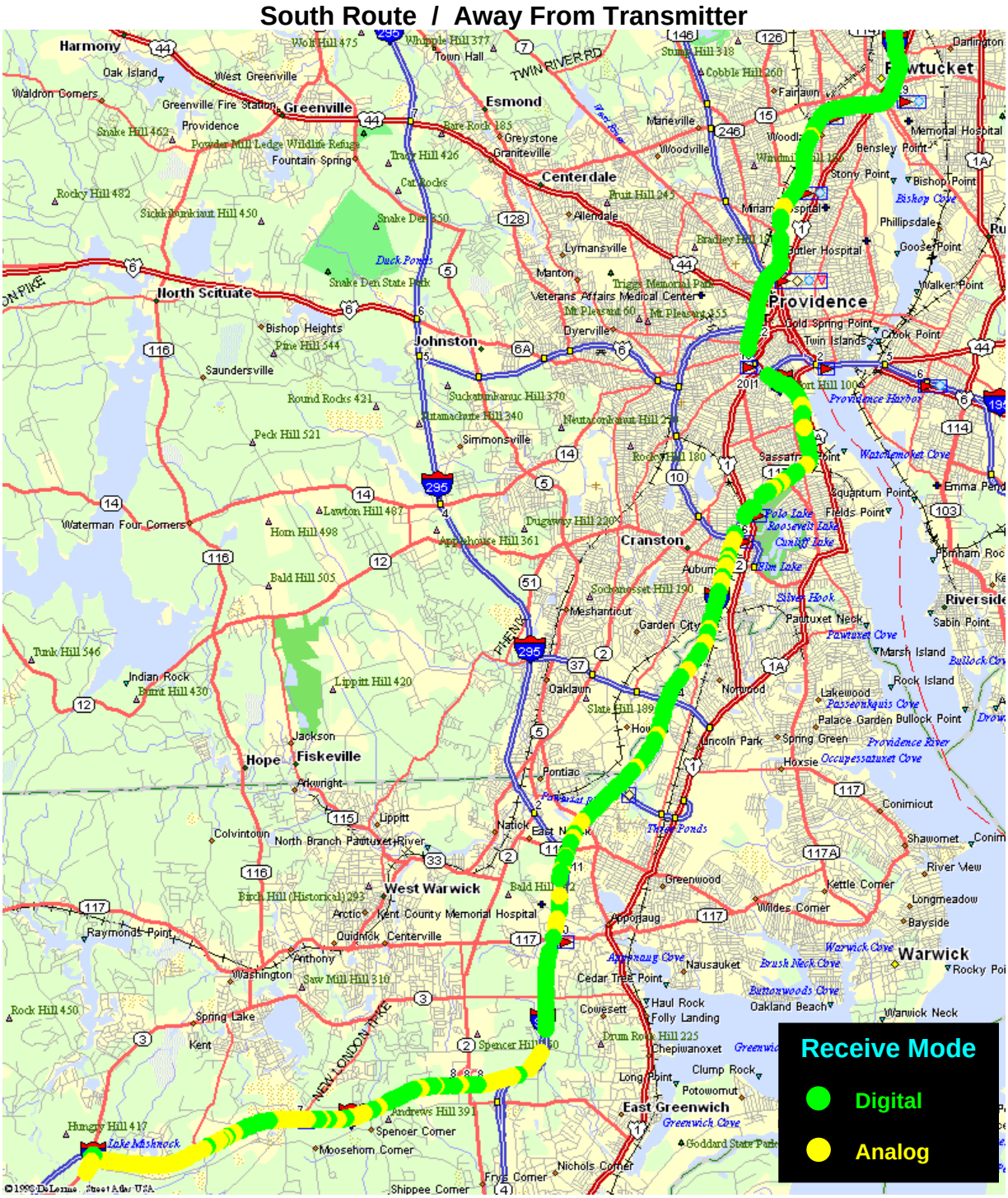
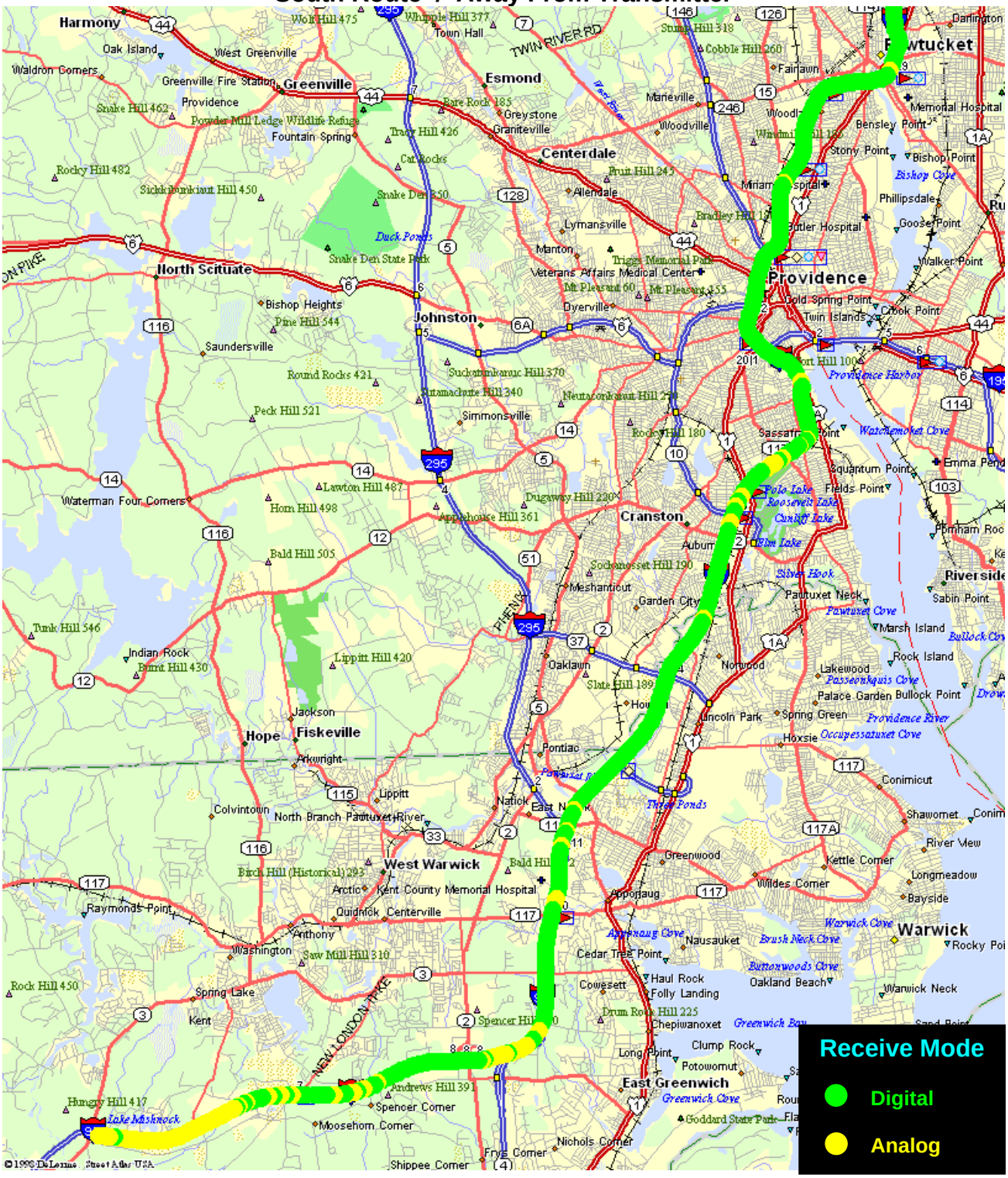


Figure 10. South Route, driving away – symmetric sidebands

Figure 10 shows the South route which follows I-95 through Pawtucket and Providence, Rhode Island and eventually ends at the intersection of Route 3. Note that south of Providence, the receiver experiences interference from an upper first-adjacent interferer: WRNI 102.7 MHz.

South Route / Away From Transmitter



WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)

Figure 11. South Route, driving away – asymmetric sidebands

Compare the map in Figure 11 with the previous symmetric run in Figure 10. The additional power in the lower, unimpaired sideband improved overall robustness, especially at the edge of coverage.

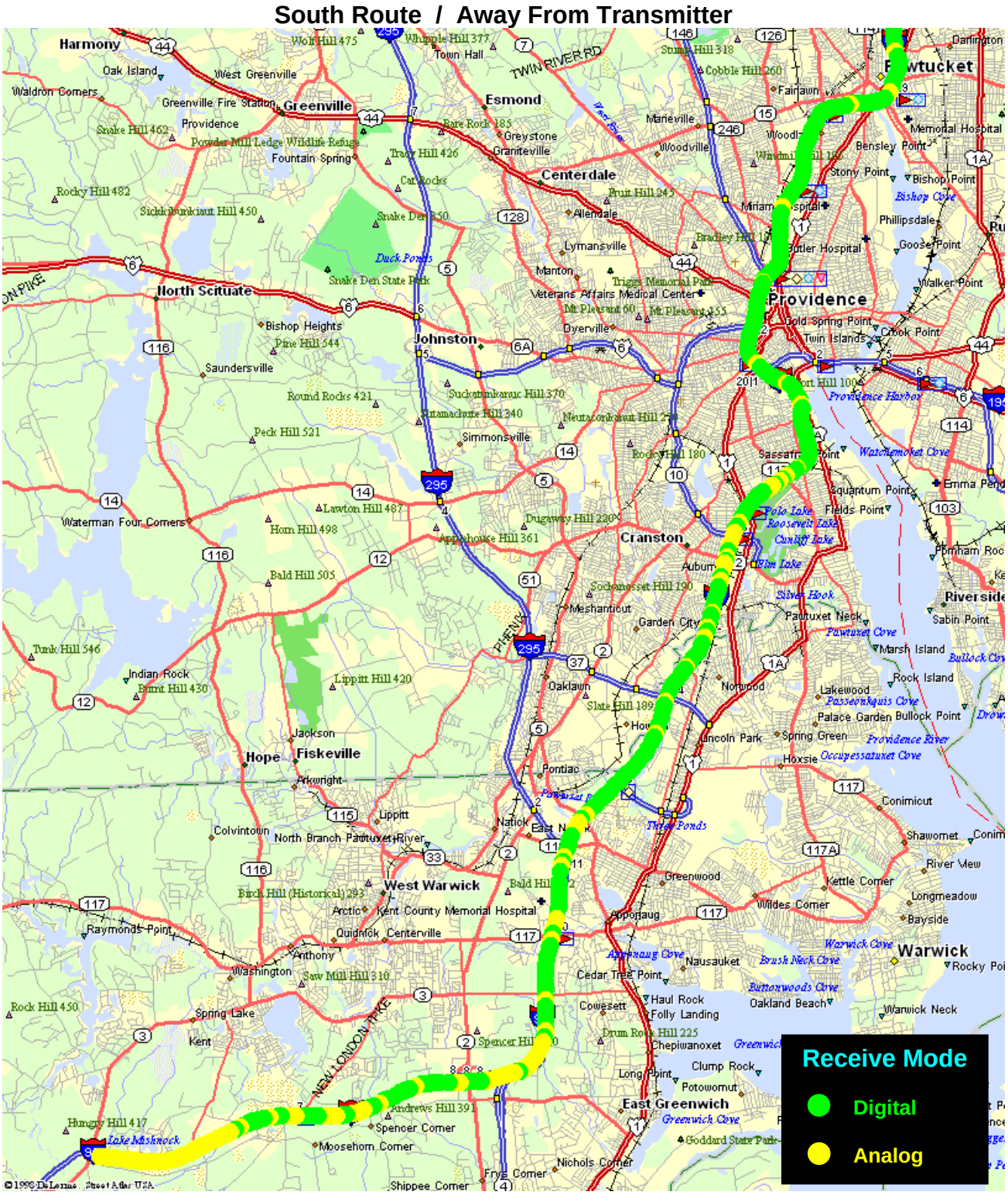
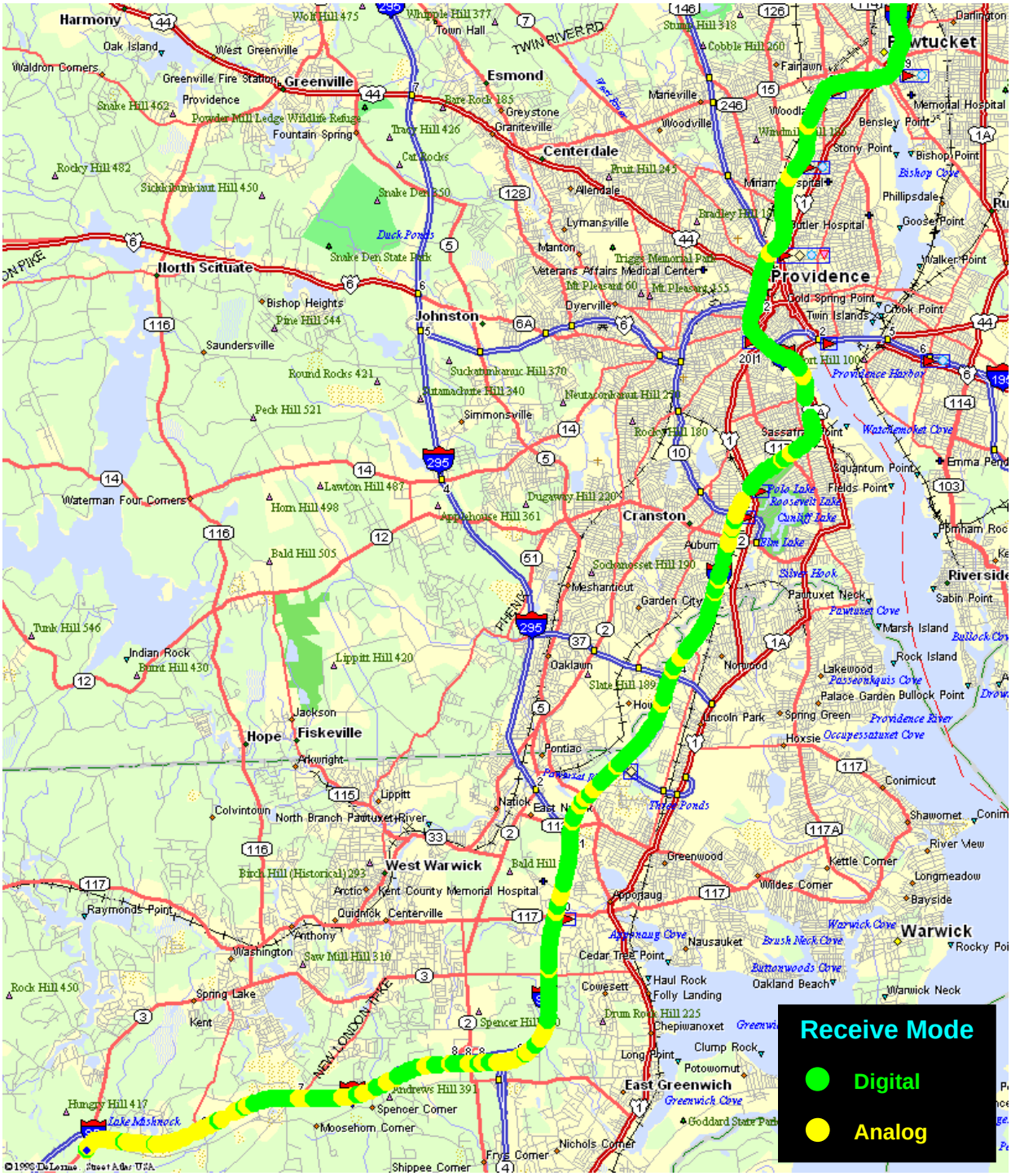


Figure 12. South Route, driving away – asymmetric sidebands, total power equivalent to symmetric

Compare the map in Figure 12 to the symmetric run in Figure 10. Coverage is very slightly diminished due to a slight loss in coding gain due to the asymmetry.

South Route / Toward Transmitter

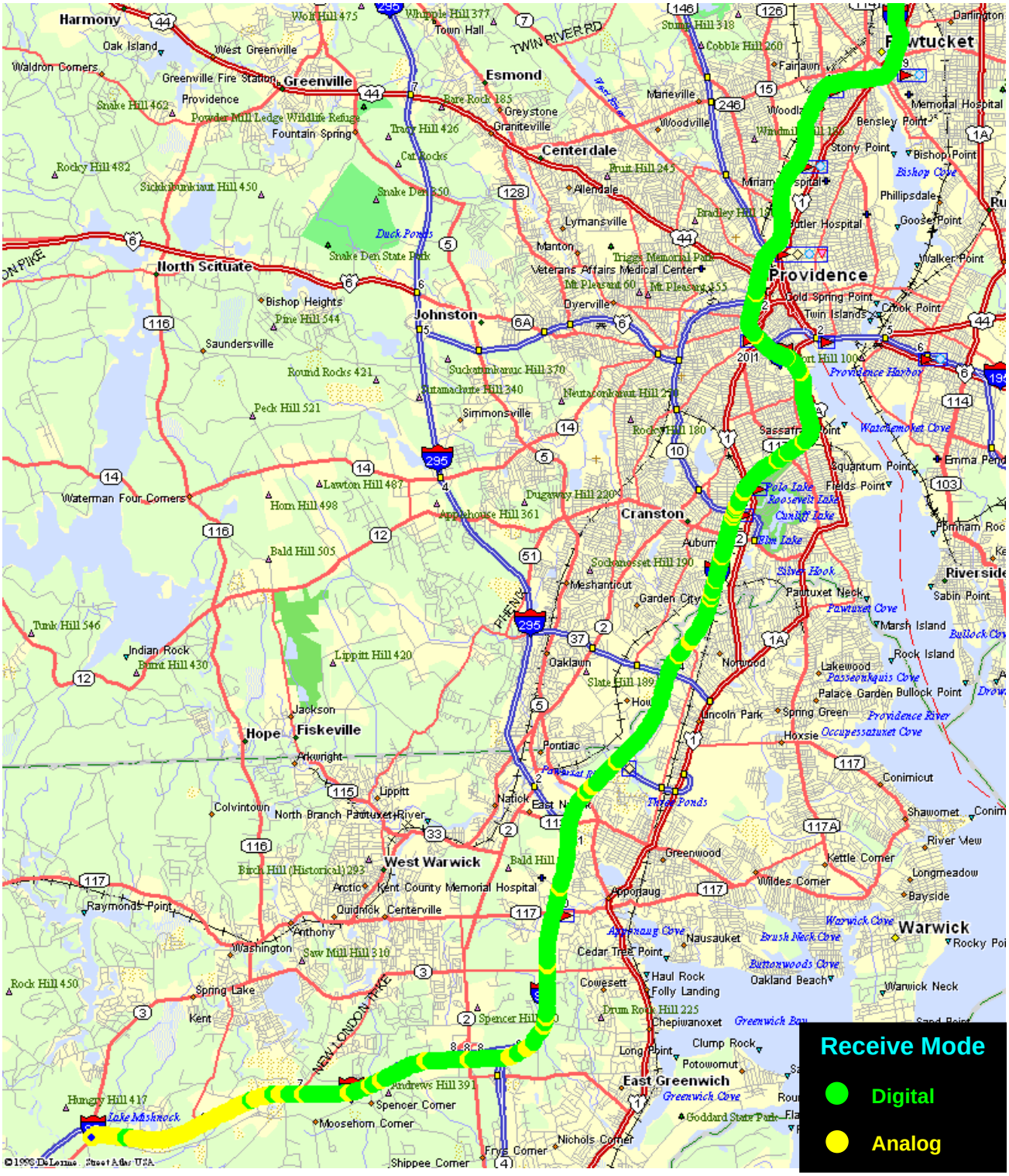


WKLB @ -17 dBc / -17 dBc (-14 dBc total)

Figure 13. South Route, driving towards – symmetric sidebands

The symmetric power run shown in Figure 13 follows I-95 from the Route 3 intersection through Providence and Pawtucket, Rhode Island and eventually ends at the I-495 intersection. The start of the run, south of Warwick, experiences interference from an upper first-adjacent interferer: WRNI 102.7 MHz.

South Route / Toward Transmitter

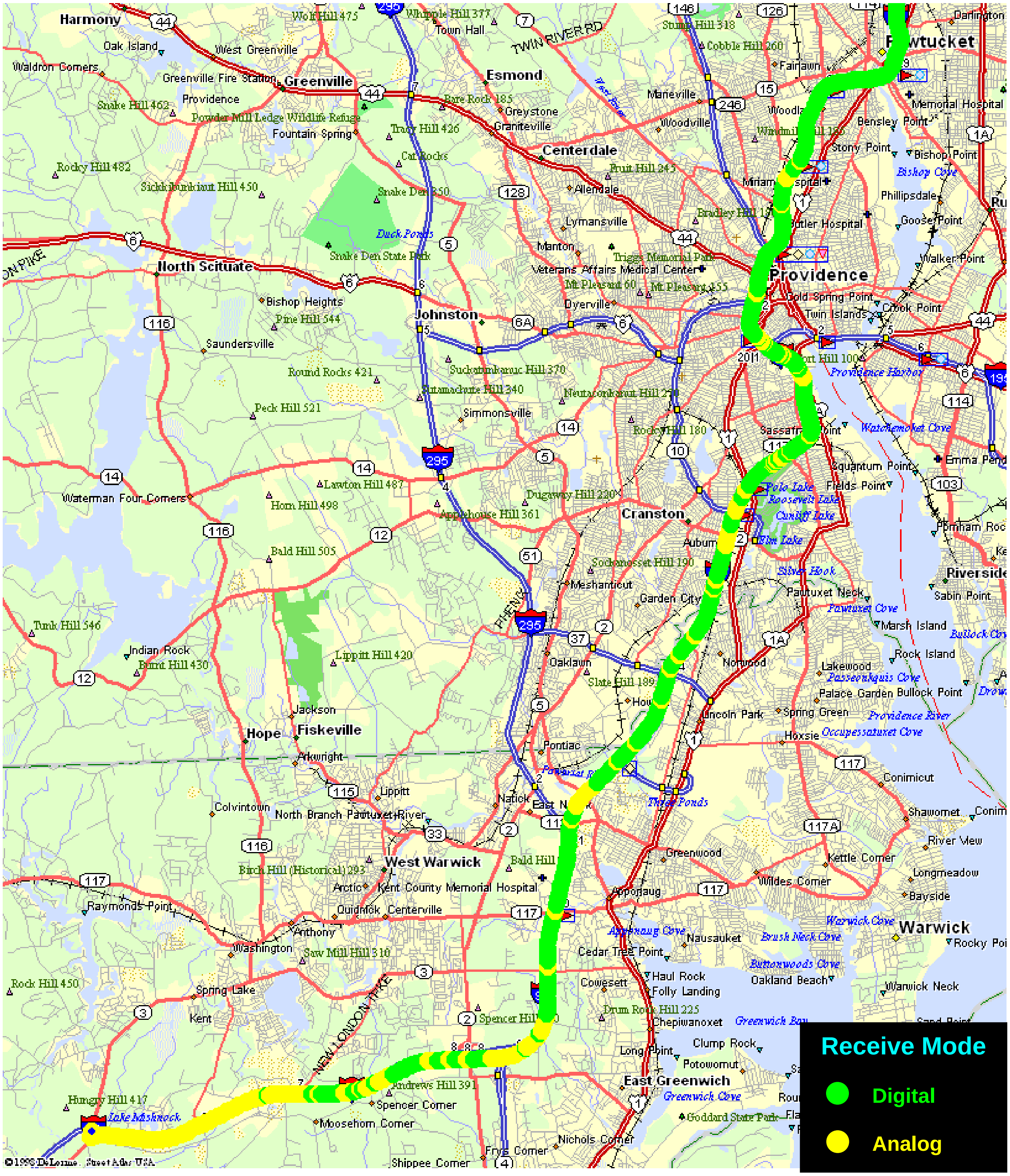


WKLB @ -13.75 dBc / -17 dBc (-12.1 dBc total)

Figure 14. South Route, driving towards – asymmetric sidebands

Compare the map in Figure 14 with the previous symmetric run in Figure 13. The additional power in the lower, unimpaired sideband improved overall robustness, especially at the edge of coverage.

South Route / Toward Transmitter



WKLB @ -15.65 dBc / -18.9 dBc (-14 dBc total)

Figure 15. South Route, driving towards – asymmetric sidebands, total power equivalent to symmetric

Compare the map in Figure 15 to the symmetric run in Figure 13. Coverage is very slightly diminished due to a slight loss in coding gain due to the asymmetry.