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Identifying and Locating Cable TV Interference

A Primer for Public Safety Engineers and Cellular Operators

Introduction

In the early days of cable TV systems, the signals being sent over the cables were the same signals that were transmitted over the air. This minimized the extent of interference problems. Problems in those days would often manifest as ghosting and would look like a multipath reflection. However as cable TV systems offered more and more TV channels and other services, signals transmitted over the cables covered virtually the entire spectrum from 7 MHz to over 1 GHz. See table 1. There are many different services that operate over the air in that frequency range. All those services can be subject to interfering signals radiating from cable TV systems and in turn over the air signals can leak into the cable TV plant and cause interference.

As cable TV systems began to expand the frequency range in the cable, interference started to be experienced by aeronautical users in the 100 to 140 MHz range and amateur radio operators in the 50 MHz to 54 MHz, 144 to 148 MHz, 220 to 225 MHz, and the 440 to 450 MHz bands. First responders could also experience interference when operating near a leaky cable plant.

Problems in the 700 and 850 MHz cellular bands emerged as the frequencies in the cables were pushed higher and higher to provide more channels for cable TV customers. As the 600 MHz frequency range begins to be used by cellular operators, problems are likely to be seen there as well.

The cable TV industry calls signals that radiate from their systems “egress” and the introduction of undesired signals into their cable “ingress.” A susceptible point in a cable plant can have both ingress and egress problems. The FCC has rules that spell out the maximum amplitude of signals radiating from cable TV systems. The rules are in part 76 of the FCC rules, specifically in §76.605, which lays out the technical standards to which cable TV operators in the United States must comply. Paragraph 12 in 76.605 says:

> 12) As an exception to the general provision requiring measurements to be made at subscriber terminals, and without regard to the type of signals carried by the cable television system, signal leakage from a cable television system shall be measured in accordance with the procedures outlined in §76.609(h) and shall be limited as follows:

Frequencies	Signal leakage limit (micro-volt/meter)	Distance in meters (m)
Less than and including 54 MHz, and over 216 MHz	15	30
Over 54 up to and including 216 MHz	20	3

Note that the entire radio frequency spectrum is included in this specification. The leakage limits are tighter in the range typically used for aeronautical communications. There is a standard method of measuring leakage from a cable TV plant and it is spelled out in paragraph §76.609(h) of the FCC rules.

> To demonstrate compliance with §76.605(a)(9), the operator of a cable television system shall attach either such manufacturer's specifications or laboratory measurements as an exhibit to each proof-of-performance record.
>
> (h) Measurements to determine the field strength of the signal leakage emanated by the cable television system shall be made in accordance with standard engineering procedures. Measurements made on frequencies above 25 MHz shall include the following:
>
> (1) A field strength meter of adequate accuracy using a horizontal dipole antenna shall be employed.
>
> (2) Field strength shall be expressed in terms of the rms value of synchronizing peak for each cable television channel for which signal leakage can be measured.
>
> (3) The resonant half wave dipole antenna shall be placed 3 meters from and positioned directly below the system components and at 3 meters above ground. Where such placement results in a separation of less than 3 meters between the center of the dipole antenna and the system components, or less than 3 meters between the dipole and ground level, the dipole shall be repositioned to provide a separation of 3 meters from the system components at a height of 3 meters or more above ground.
>
> (4) The horizontal dipole antenna shall be rotated about a vertical axis and the maximum meter reading shall be used.
>
> (5) Measurements shall be made where other conductors are 3 or more meters (10 or more feet) away from the measuring antenna.

What is Interference?

RF Interference occurs when an unwanted RF signal enters the front end of a radio receiver and either causes the receiver sensitivity to lower (De-Sense) or prohibits reception completely (Receiver Blocking). Even when a cable TV plant is technically in compliance with FCC rules, there still can be interference given the right circumstances. For example, if a police car is near a leaky point in the cable plant, the radiated emission may block or degrade desired communications.

Coaxial cable is usually well shielded and the high quality coax cables used in cable TV installations generally exhibit very low leakage. However, the outer conductor is subject to many environmental stresses which can compromise the integrity of the cable and thereby increase leakage. Stresses on the outer conductor include wind, rain, hail, squirrels (they will actually eat the shield!) and vandalism, including the cable being shot.

Cable TV plants are regularly checked for leakage at aeronautical frequencies. Cable TV service trucks are often equipped with receivers to check for leakage during the normal course of business. Annually, either a flyover is done or ground based measurements are used and turned into a measure called the Cumulative Leakage Index (CLI) using calculations that are spelled out in §76.611.

In §76.612 the FCC sets out cable TV frequency separation standards so signals on the cable are offset from over-the-air channels. Doing so places signals in the cable halfway between over-the-air channels in the 108 to 118 MHz, 118 to 137 MHz and 225 to 400 MHz aeronautical communication bands. This is done to minimize interference. However, a cable plant that is in compliance in the aeronautical frequency ranges may have excessive leakage at higher frequencies since the wavelengths are shorter and leakage can occur more easily.

Some cable TV systems have been in operation since the 1960s and as a result some of their cable plant is quite old. Aging cables and the connectors attach to them tend to degrade so leakage becomes worse over time. Even worse, the connections made by cable TV customers may be poorly done. They might have used cheap, substandard coax such as cheap RG-59 coax instead of RG-6. They may have used unshielded cables, 300 ohm twin lead or even power cord (zip cord). Customers sometimes add poor quality splitters to feed additional TVs or even run a cable to their next door neighbor’s house to give them cable TV.

The issues on a cable TV system can be isolated or pervasive. An old coax-only cable TV system may have been well maintained, but has been pushed to higher frequencies to expand offerings to their customers. Or it could have been neglected for years, only reacting to customer complaints and doing the minimum maintenance necessary to keep from losing too many customers. The leakage from older systems may well be pervasive because they weren't built to operate cleanly up to 1 GHz and have small leaks all over the plant. In addition, loose coax connectors, newly installed amplifiers with an unterminated output, and improper customer additions can be isolated problems. Abuse or damage to the outer conductor of coax cable (such as cracks in the outer conductor of semi-rigid coax) in the cable plant can also manifest as isolated problems.

An interference hunt will need to be done for both types of problems. Using Anritsu's Mobile InterferenceHunter (MIH) as an example, an isolated problem may be hunted as a single point emitter while pervasive problems are hunted using the multipoint emitter mode.

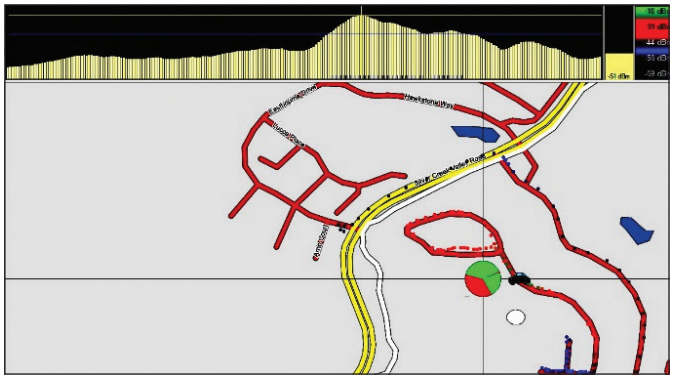

Figure 1. Single point emitter

Figure 2. Multipoint emitter

Interference problems always have three components. First, a piece of susceptible equipment, second, a source of radio-frequency energy or electrical noise, and finally a path over which the unwanted energy is propagated. To solve an interference problem changes need to be made to one or more of these three components.

Why this causes problems for mobile network operators

The uplink signal going from a handset to a base station can be very low amplitude at the base station. A cable leak can potentially be much larger if the point of leakage is near the base station. This would manifest as poor coverage for a sector or sectors that are near egress points with users near the edge of a base stations coverage area experiencing dropped or blocked calls and reduced data rates. LTE is particularly susceptible to interference because LTE was designed to get high data rates at the cost of lower robustness of the signal.

There can also be problems on the downlink if there are a lot of leaks in the coverage area. A user near one of the leakage points may experience the same issues as on the uplink described in the previous paragraph.

Why Cable TV Operator Look for Leakage (Egress)

Egress is like a canary in a coal mine. If a cable plant has leakage there may be other problems in the same area. There may be ingress causing signal degradation for their customers, there may be harmful interference to first responders. Leakage may lead to substantial fines levied by the FCC or other regulatory agency such as the FAA. Fines levied by the FCC can be as much as $20,000 per day, so it is in a cable TV company's best interest to resolve interference issues promptly. In addition to causing interference, problems in a section of cable may also cause dropouts or other degradation on some TV channels because of ingress.

What the signals look like

In any interference hunting situation, it is important to know what the signals you are hunting look like. In North America most television signals are digital, although there are many closed circuit analog systems still in use. Many of the analog signals are from security and surveillance systems.

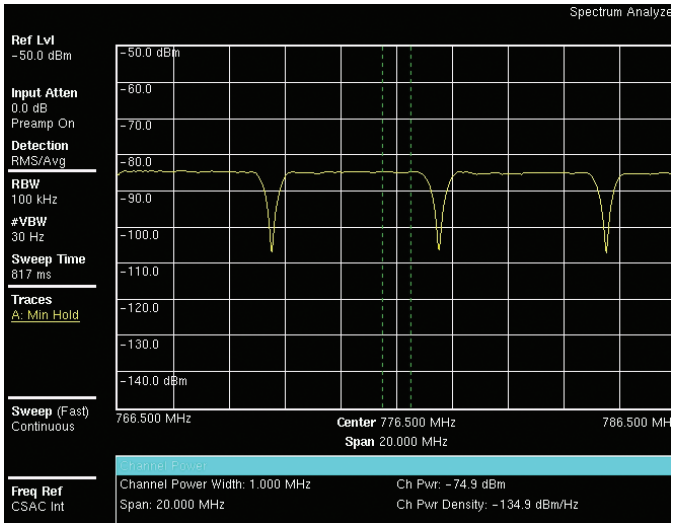

Figure 3. Ideal digital TV signals

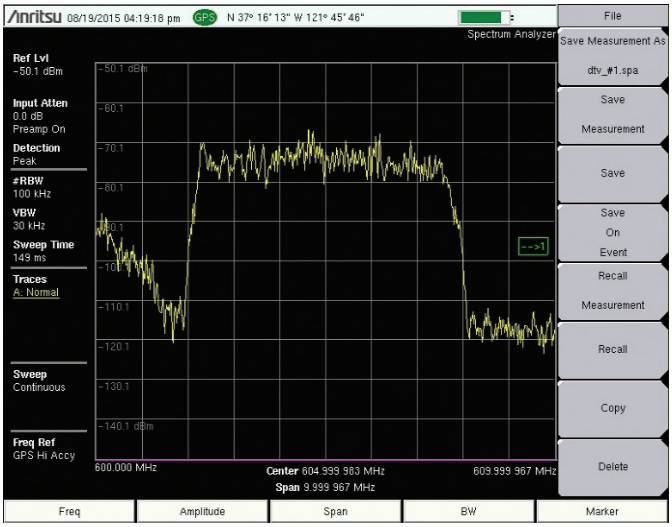

Figure 4. Over-the-air digital TV signal.

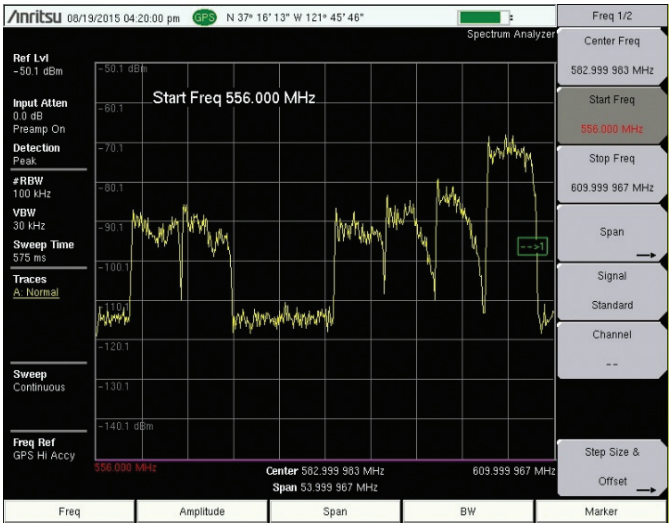

Figure 5. Over-the-air multiple digital TV channels

Using Anritsu's Mobile InterferenceHunter to locate Emitters

The simplest process is to find and fix problems one at a time using the single emitter mode in Anritsu's Mobile InterferenceHunter. If there are many emitters this can be very time consuming and it may be confusing if multiple points of emission are close together.

The most comprehensive process is to survey entire coverage area of affected cells or sectors, but again this can be very time consuming. To do this, use entry level staff to drive the roads in the affected area while using the Anritsu Mobile InferferenceHunter set to multi-emitter mode.

After the drive is complete, interference hunting experts can review the data that was gathered. From that review, choose the location or locations to be visited by expert interference hunters. The hunters should expect to go on foot after they determine the most likely hunting location using single emitter mode in the MIH.

The gathered data can be analyzed either as a single point emitter or multi-point emitter after the fact. However the data that the software takes is different for the two choices. So it is better to gather data for the more probable interference case.

The optimal method may vary, but a reasonable process is to first determine if you have a single-emitter or multi-emitter problem by

- Seeing if multiple sectors or nearby base stations are affected in a similar way. If so it's probably a multi-emitter problem.
- If you find and fix one or several problems, and you still see the signal at the base station, it's a multi-emitter problem.
- If you have new spectrum available, and you want to clear the spectrum of other users before you start using it yourself, this is very likely to be a multi-emitter problem. This can be true for both cable TV egress and other emitters.
- If you know that the cable plant in a particular area is old and poorly maintained, and you are seeing the signal at multiple base stations, you might as well treat it as a multi-emitter problem.

Figure 6. Multi-point measurement of a clean cable plant

Using Single-Emitter Mode

In single emitter mode, the MIH software sets up the spectrum analyzer to do channel power measurements at the center frequency you select. One of the critical requirements for a successful hunt is to have the analyzer set up to deliver a stable power measurement when the vehicle is stopped. To meet this requirement select a narrow VBW to smooth out the measurements. A small amount of trace averaging can be used although averaging is slower than using the narrow VBW.

Select a quiet frequency that is in a guard band between over the air signals, otherwise your hunt will be confounded by signals other than those you are hunting. This approach works because leakage from the cable plant will usually cover a broad frequency range. The hunt does NOT have to be done at the frequency at which you are experiencing interference.

Setting up the MIH for Single Emitter hunting

For single emitter hunting, set up in spectrum analyzer mode at a frequency that is quiet and has no significantly large over-the-air signals that could compete with the hunt for leakage. Ideally there would be no detectable over-the-air signals at the measurement frequency. The easiest way to find a clear frequency is to use a guard band between two TV channels. Finding a clear frequency may take a bit of over the air work well away from the suspected location of the egress signal that is being sought.

In the United States, 608 to 614 MHz is a quiet band because it is assigned to radio astronomy. The only other use in the U.S. is for patient telemetry systems in hospitals. These frequencies are used in many cable TV systems, so it may be a good place to start when looking for a quiet frequency range. Measurements in the San Jose, California area confirm that the frequency range is very quiet. The only place that signals may be found is near hospitals.

Set the span to a narrow enough value that the signal being hunted is the only signal visible. Any other signals present will compromise the integrity of the measurements. Set RBW to auto and set a narrow VBW value so the instrument delivers a stable power reading when stopped. A 300 Hz VBW is a good starting value.

Connect a GPS antenna and wait for GPS lock. Connect the instrument to the laptop or tablet with a 5-pin mini-USB cable, Anritsu part number 3-2000-1498.

After starting the MIH, set it to single emitter mode and choose a map that cover the geographical area of interest. Zoom in sufficiently to clearly see streets. Click or tap on the automobile icon to center your current location on the map.

MIH sets the instrument to measure channel power across the span you select. It also sets the detection mode to RMS Average.

Using Multi-Emitter mode

In the pervasive interference case, multi-emitter mode is invaluable. With the potential of several or many points of egress in a cable TV plant, being able to locate many possible locations in a single drive is a great time and money saver. The idea is to use low-cost staff to drive all the roads covered by the cable plant while automatically gathering data. In the multi-emitter mode a red X marks the spot where there may be egress. In figure 7 observe the yellow lines at the top of the display. They indicate local peaks in the measurements and are marked as potential locations.

Figure 7. Multi-emitter Measurement

Sometimes it can be useful to look at the same measurements in Spectrum Clearing mode as shown in Figure 8. In this mode the trends in the measurements are more important than the exact location of the emitter. Please note:

- MIH can also capture spectrum as you are driving. {Click on the power bar to see the location & spectrum associated with that time.)
- In Spectrum Clearing mode, you can capture the spectrum display as a screenshot for signals that are above the threshold.

Figure 8. Viewing a multi-emitter measurement using Spectrum Clearing Mode

Fixing the problem

Once a problem has been found, the next step is to contact the cable TV company. Since minimizing ingress is important to the companies, and egress problems may also indicate ingress issues, they are usually good about fixing problems once they know about them. Be sure that the person you are talking to has the authority to get an interference hunt started. In some countries the cable TV operator and the mobile operators are the same companies so they tend to be motivated to keep their cable plants clean.

In many countries the local regulatory agencies have the authority to levy fines or even jail time for violation of the rules. If a cable TV company is uncooperative in resolving interference issues, reminding them of the potential of having fines or jail time may be enough to get issues fixed. That is not true in all countries. In those countries diplomacy may be needed to gain cooperation. You also may need to lobby the regulatory agency to develop better regulations to protect all licensed spectrum users from harmful interference. Pointing out that you have paid a license fee for the use of the spectrum may be sufficient to influence your regulator agency to do something.

The FCC rules can serve as a good model to help agencies develop their own regulations. In terms of interference issues, paragraph §76.605(a)12 is a good place to start. Most of part 76 deals with issues such as the quality of the signal in the cable, billing and customer support. Wholesale adoption of the rules by another agency may not be warranted.

Conclusion

Ultimately interference from a cable TV system can be resolved. It may not be quick or easy, but it can be done.

As you are going through the interference hunting process be sure to keep good records of your work since it may be needed to either help the cable TV repair technicians find the problem. The records may be needed to show the FCC enforcement engineers or as legal evidence if it comes to that.

Table 1. TV Channel frequencies in North America

The frequencies shown in this table apply to both NTSC-based analog television and QAM-based digital television.

- Band plans for North American cable television systems are standardized in EIA standard 542-B.[12]
- Channels 57 to 61, and 143 to 145, are used in Amateur Television.
- NOTE: Frequencies given are for luminance carriers. For channel center frequencies, add 1.75 MHz.

Channel Number	Channel Letter	STD Video Carrier (MHz)	HRC Video Carrier (MHz)	IRC Video Carrier (MHz)	QAM / CDSREF Carrier (MHz)	Audio Carrier (MHz)
			Subband "T" Channels			
	T-7	7.00				
	T-8	13.00				
	T-9	19.00				
	T-10	25.00				
	T-11	31.00				
	T-12	37.00				
	T-13	43.00				
	T-14	49.00				
			(Break in band plan)			
Lowband						
2	2	55.25	54.0027	55.25	57.00	59.75
3	3	61.25	60.0030	61.25	63.00	65.75
4	4	67.25	66.0033	67.25	69.00	71.75
1	A-8	n/a	72.0036	73.25	75.00	77.75
5	5 (or A-7)	77.25	78.0039	79.25	79.00 or 81.00	81.75 or 83.75
6	6 (or A-6)	83.25	84.0042	85.25	85.00 or 87.00	87.75 or 89.75
Midband						
95	A-5	91.25	90.0045	91.25	93.00	95.75
96	A-4	97.25	96.0048	97.25	99.00	101.75
97	A-3	103.25	102.0051	103.25	105.00	107.75
98	A-2	109.25	108.0054	109.25	111.00	113.75
99	A-1	115.25	114.0057	115.25	117.00	119.75
Midband						
14	A	121.25	120.0060	121.25	123.00	125.75
15	B	127.25	126.0063	127.25	129.00	131.75
16	C	133.25	132.0066	133.25	135.00	137.75
17	D	139.25	138.0069	139.25	141.00	143.75
18	E	145.25	144.0072	145.25	147.00	149.75
19	F	151.25	150.0075	151.25	153.00	155.75
20	G	157.25	156.0078	157.25	159.00	161.75
21	H	163.25	162.0081	163.25	165.00	167.75
22	I	169.25	168.0084	169.25	171.00	173.75
Highband						
7	7	175.25	174.0087	175.25	177.00	179.75
8	8	181.25	180.0090	181.25	183.00	185.75
9	9	187.25	186.0093	187.25	189.00	191.75
10	10	193.25	192.0096	193.25	195.00	197.75
11	11	199.25	198.0099	199.25	201.00	203.75
12	12	205.25	204.0102	205.25	207.00	209.75
13	13	211.25	210.0105	211.25	213.00	215.75

Continued

Superband						
23	J	217.25	216.0108	217.25	219.00	221.75
24	K	223.25	222.0111	223.25	225.00	227.75
25	L	229.25	228.0114	229.25	231.00	233.75
26	M	235.25	234.0117	235.25	237.00	239.75
27	N	241.25	240.0120	241.25	243.00	245.75
28	O	247.25	246.0123	247.25	249.00	251.75
29	P	253.25	252.0126	253.25	255.00	257.75
30	Q	259.25	258.0129	259.25	261.00	263.75
31	R	265.25	264.0132	265.25	267.00	269.75
32	S	271.25	270.0135	271.25	273.00	275.75
33	T	277.25	276.0138	277.25	279.00	281.75
34	U	283.25	282.0141	283.25	285.00	287.75
35	V	289.25	288.0144	289.25	291.00	293.75
36	W	295.25	294.0147	295.25	297.00	299.75
Hyperband						
37	AA or W+1	301.25	300.0150	301.25	303.00	305.75
38	BB or W+2	307.25	306.0153	307.25	309.00	311.75
39	CC or W+3	313.25	312.0156	313.25	315.00	317.75
40	DD or W+4	319.25	318.0159	319.25	321.00	323.75
41	EE or W+5	325.25	324.0162	325.25	327.00	329.75
42	FF or W+6	331.25	330.0165	331.25	333.00	335.75
43	GG or W+7	337.25	336.0168	337.25	339.00	341.75
44	HH or W+8	343.25	342.0171	343.25	345.00	347.75
45	II or W+9	349.25	348.0174	349.25	351.00	353.75
46	JJ or W+10	355.25	354.0177	355.25	357.00	359.75
47	KK or W+11	361.25	360.0180	361.25	363.00	365.75
48	LL or W+12	367.25	366.0183	367.25	369.00	371.75
49	MM or W+13	373.25	372.0186	373.25	375.00	377.75
50	NN or W+14	379.25	378.0189	379.25	381.00	383.75
51	OO or W+15	385.25	384.0192	385.25	387.00	389.75
52	PP or W+16	391.25	390.0195	391.25	393.00	395.75
53	QQ or W+17	397.25	396.0198	397.25	399.00	401.75
54	RR or W+18	403.25	402.0201	403.25	405.00	407.75
55	SS or W+19	409.25	408.0204	409.25	411.00	413.75
56	TT or W+20	415.25	414.0207	415.25	417.00	419.75
57	UU or W+21	421.25	420.0210	421.25	423.00	425.75
58	VV or W+22	427.25	426.0213	427.25	429.00	431.75
59	WW or W+23	433.25	432.0216	433.25	435.00	437.75
60	XX or W+24	439.25	438.0219	439.25	441.00	443.75
61	YY or W+25	445.25	444.0222	445.25	447.00	449.75
62	ZZ or W+26	451.25	450.0225	451.25	453.00	455.75
63	AAA or W+27	457.25	456.0228	457.25	459.00	461.75
64	BBB or W+28	463.25	462.0231	463.25	465.00	467.75
Ultraband						
65	CCC or W+29	469.25	468.0234	469.25	471.00	473.75
66	DDD or W+30	475.25	474.0237	475.25	477.00	479.75
67	EEE or W+31	481.25	480.0240	481.25	483.00	485.75
68	FFF or W+32	487.25	486.0243	487.25	489.00	491.75

Continued

69	GGG or W+33	493.25	492.0246	493.25	495.00	497.75
70	HHH or W+34	499.25	498.0249	499.25	501.00	503.75
71	III or W+35	505.25	504.0252	505.25	507.00	509.75
72	JJJ or W+36	511.25	510.0255	511.25	513.00	515.75
73	KKK or W+37	517.25	516.0258	517.25	519.00	521.75
74	LLL or W+38	523.25	522.0261	523.25	525.00	527.75
75	MMM or W+39	529.25	528.0264	529.25	531.00	533.75
76	NNN or W+40	535.25	534.0267	535.25	537.00	539.75
77	OOO or W+41	541.25	540.0270	541.25	543.00	545.75
78	PPP or W+42	547.25	546.0273	547.25	549.00	551.75
79	QQQ or W+43	553.25	552.0276	553.25	555.00	557.75
80	RRR or W+44	559.25	558.0279	559.25	561.00	563.75
81	SSS or W+45	565.25	564.0282	565.25	567.00	569.75
82	TTT or W+46	571.25	570.0285	571.25	573.00	575.75
83	UUU or W+47	577.25	576.0288	577.25	579.00	581.75
84	VVV or W+48	583.25	582.0291	583.25	585.00	587.75
85	WWW or W+49	589.25	588.0294	589.25	591.00	593.75
86	XXX or W+50	595.25	594.0297	595.25	597.00	599.75
87	YYY or W+51	601.25	600.0300	601.25	603.00	605.75
88	ZZZ or W+52	607.25	606.0303	607.25	609.00	611.75
89	89 or W+53	613.25	612.0306	613.25	615.00	617.75
90	90 or W+54	619.25	618.0309	619.25	621.00	623.75
91	91 or W+55	625.25	624.0312	625.25	627.00	629.75
92	92 or W+56	631.25	630.0315	631.25	633.00	635.75
93	93 or W+57	637.25	636.0318	637.25	639.00	641.75
94	94 or W+58	643.25	642.0321	643.25	645.00	647.75
Jumboband						
100	100 or W+59	649.25	648.0324	649.25	651.00	653.75
101	101 or W+60	655.25	654.0327	655.25	657.00	659.75
102	102 or W+61	661.25	660.0330	661.25	663.00	665.75
103	103 or W+62	667.25	666.0333	667.25	669.00	671.75
104	104 or W+63	673.25	672.0336	673.25	675.00	677.75
105	105 or W+64	679.25	678.0339	679.25	681.00	683.75
106	106 or W+65	685.25	684.0342	685.25	687.00	689.75
107	107 or W+66	691.25	690.0345	691.25	693.00	695.75
108	108 or W+67	697.25	696.0348	697.25	699.00	701.75
109	109 or W+68	703.25	702.0351	703.25	705.00	707.75
110	110 or W+69	709.25	708.0354	709.25	711.00	713.75
111	111 or W+70	715.25	714.0357	715.25	717.00	719.75
112	112 or W+71	721.25	720.0360	721.25	723.00	725.75
113	113 or W+72	727.25	726.0363	727.25	729.00	731.75
114	114 or W+73	733.25	732.0366	733.25	735.00	737.75
115	115 or W+74	739.25	738.0369	739.25	741.00	743.75
116	116 or W+75	745.25	744.0372	745.25	747.00	749.75
117	117 or W+76	751.25	750.0375	751.25	753.00	755.75
118	118 or W+77	757.25	756.0378	757.25	759.00	761.75
119	119 or W+78	763.25	762.0381	763.25	765.00	767.75
120	120 or W+79	769.25	768.0384	769.25	771.00	773.75
121	121 or W+80	775.25	774.0387	775.25	777.00	779.75

Continued

122	122 or W+81	781.25	780.0390	781.25	783.00	785.75
123	123 or W+82	787.25	786.0393	787.25	789.00	791.75
124	124 or W+83	793.25	792.0396	793.25	795.00	797.75
125	125 or W+84	799.25	798.0399	799.25	801.00	803.75
126	126 or W+85	805.25	804.0402	805.25	807.00	809.75
127	127 or W+86	811.25	810.0405	811.25	813.00	815.75
128	128 or W+87	817.25	816.0408	817.25	819.00	821.75
129	129 or W+88	823.25	822.0411	823.25	825.00	827.75
130	130 or W+89	829.25	828.0414	829.25	831.00	833.75
131	131 or W+90	835.25	834.0417	835.25	837.00	839.75
132	132 or W+91	841.25	840.0420	841.25	843.00	845.75
133	133 or W+92	847.25	846.0423	847.25	849.00	851.75
134	134 or W+93	853.25	852.0426	853.25	855.00	857.75
135	135 or W+94	859.25	858.0429	859.25	861.00	863.75
136	136 or W+95	865.25	864.0432	865.25	867.00	869.75
137	137 or W+96	871.25	870.0435	871.25	873.00	875.75
138	138 or W+97	877.25	876.0438	877.25	879.00	881.75
139	139 or W+98	883.25	882.0441	883.25	885.00	887.75
140	140 or W+99	889.25	888.0444	889.25	891.00	893.75
141	141 or W+100	895.25	894.0447	895.25	897.00	899.75
142	142 or W+101	901.25	900.0450	901.25	903.00	905.75
143	143 or W+102	907.25	906.0453	907.25	909.00	911.75
144	144 or W+103	913.25	912.0456	913.25	915.00	917.75
145	145 or W+104	919.25	918.0459	919.25	921.00	923.75
146	146 or W+105	925.25	924.0462	925.25	927.00	929.75
147	147 or W+106	931.25	930.0465	931.25	933.00	935.75
148	148 or W+107	937.25	936.0468	937.25	939.00	941.75
149	149 or W+108	943.25	942.0471	943.25	945.00	947.75
150	150 or W+109	949.25	948.0474	949.25	951.00	953.75
151	151 or W+110	955.25	954.0477	955.25	957.00	959.75
152	152 or W+111	961.25	960.0480	961.25	963.00	965.75
153	153 or W+112	967.25	966.0483	967.25	969.00	971.75
154	154 or W+113	973.25	972.0486	973.25	975.00	977.75
155	155 or W+114	979.25	978.0489	979.25	981.00	983.75
156	156 or W+115	985.25	984.0492	985.25	987.00	989.75
157	157 or W+116	991.25	990.0495	991.25	993.00	995.75
158	158 or W+117	997.25	996.0498	997.25	999.00	1001.75

Common name	Uplink	Downlink
GSM/CDMA/WCDMA850	869-894 MHz	824-849MHz
GSM900	880-915 MHz	925-960 MHz
GSM1800	1710-1785 MHz	1805-1880 MHz
GSM/CDMA1900	1850-1910 MHz	1930-1990 MHz
WCDMA2100 (AWS)	1710-1755 MHz	2110-2170 MHz

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700 MHz a b and c blocks
850 MHz

From https://en.wikipedia.org/wiki/List_of_LTE_networks

AT&T 700 MHz block b and c band 17

BendBroadband 700 MHz block b band 17

BIT Communications 700 MHz

Bluegrass Cellular 700 MHz blocks b and c band 12 or 17

CVC 700 MHz a block band 12

Evolve Broadband block b band 17

Fuego Wireless 700 MHz a and b block band 12

AVC 700 MHz block b band 12 or 17

Mosaic Telecom 700 MHz block c band 12 or 17

Nex-Tech Wireless 700 MHz block c band 12

nTelos 700 MHz bands 12 or 17

PTCI 700 MHz blocks b or c band 12 or 17

Rock Wireless 700 MHz block a band 112

Sprint 850 MHz band 26

Syringa Wireless 700 MHz a block band 12

T-Mobile 700 MHz a block band 12

Sprint 850 MHz band 26

U.S. Cellular 850 MHz band 5

United Wireless 750 MHz c block bands 12 or 17

Verizon 700 MHz c block band 13

VTel Wireless 700 MHz c block bands 12 or 17

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11410-00907, Rev. B Printed in United States 2016-01