600 MHz PIM Analysis

Rogers Canada

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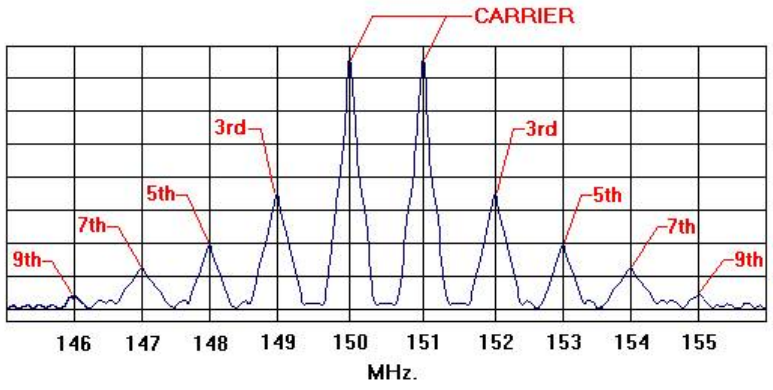
Introduction
What is passive intermodulation, PIM?

- Passive intermodulation occurs when two or more signals are present in a passive non-linear device or element
- The signals will mix or multiply with each other to generate other signals that are related to the first ones
- For two signals f1 and f2, intermodulation products can occur at ±M*f1 ± N*f2

- 3rd Order: $2f_1 - f_2$, $2f_2 - f_1$
- 5th Order: $3f_1 - 2f_2$, $3f_2 - 2f_1$
- 7th Order: $4f_1 - 3f_2$, $4f_2 - 3f_1$

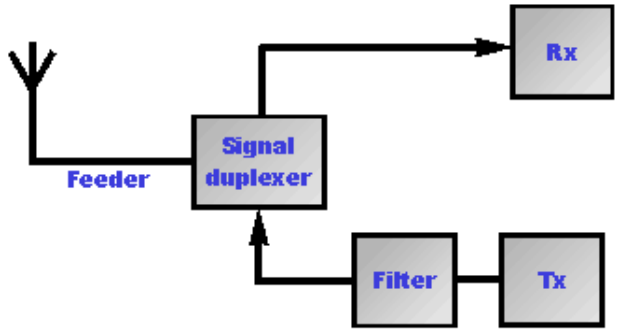


Spectural Display of Carriers and 3rd, 5th, 7th and 9th Odd Order Products

- When three or more carriers are involved, the calculations quickly become complex

Introduction
Cause of PIMs

- Signals sharing same passive device(s)
  - Transmitter and receiver use the same feeder and antenna where duplex transmission in both directions is required

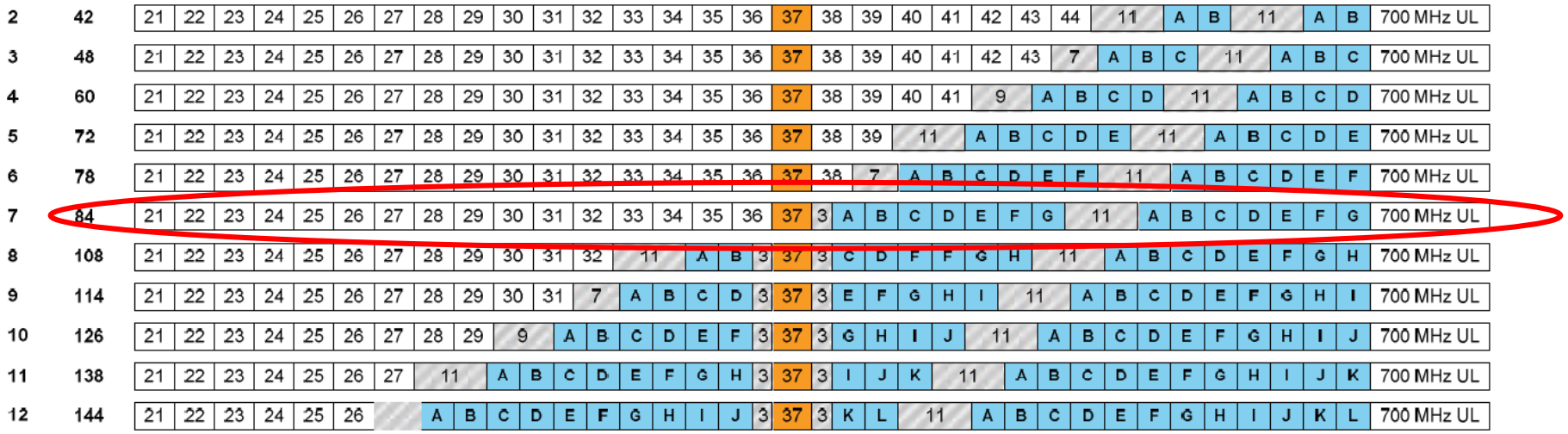


- Other causes
  - Coaxial connectors
  - Feeder lines
  - Joints of dissimilar metals
  - Dirty connections
  - Loose connections
  - General anodic effects
  - Use of ferromagnetic materials
  - Spark discharges

- PIM levels are normally low and at low power levels and PIM products may fall below the thermal noise level

600 MHz Carrier Selection

— For 600 MHz, the 7 paired block scenario is utilized



PIM Scenarios Analyzed

Baseline (without 600 MHz blocks)

Band	Block	Bandwidth DL/UL (MHz)
700L MHz	BC	10
700U MHz	C	10
AWS	A	10
850 MHz	B	10
850 MHz	b	2.5
GPS	L1	20.46
GPS	L2	20.46

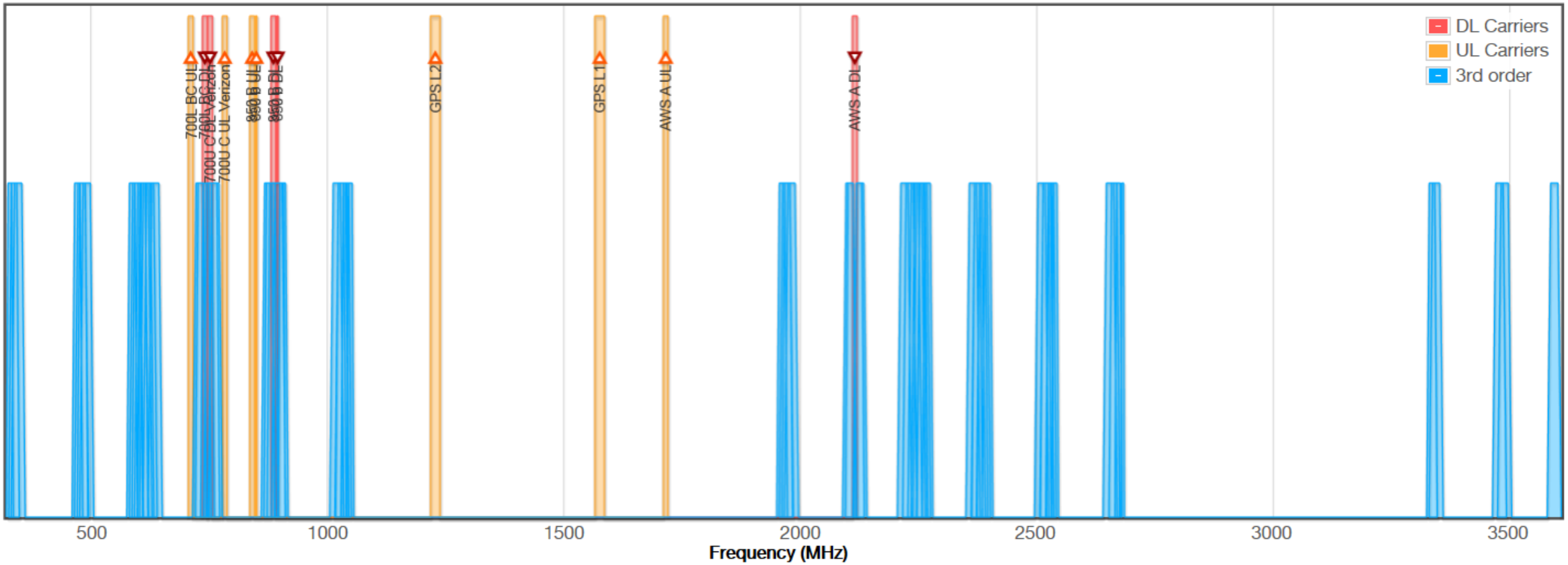
Baseline + each individual 600 MHz Block

Band	Block	Bandwidth DL/UL (MHz)
600 MHz	A	5
600 MHz	B	5
600 MHz	C	5
600 MHz	D	5
600 MHz	E	5
600 MHz	F	5
600 MHz	G	5

Frequency Utilization

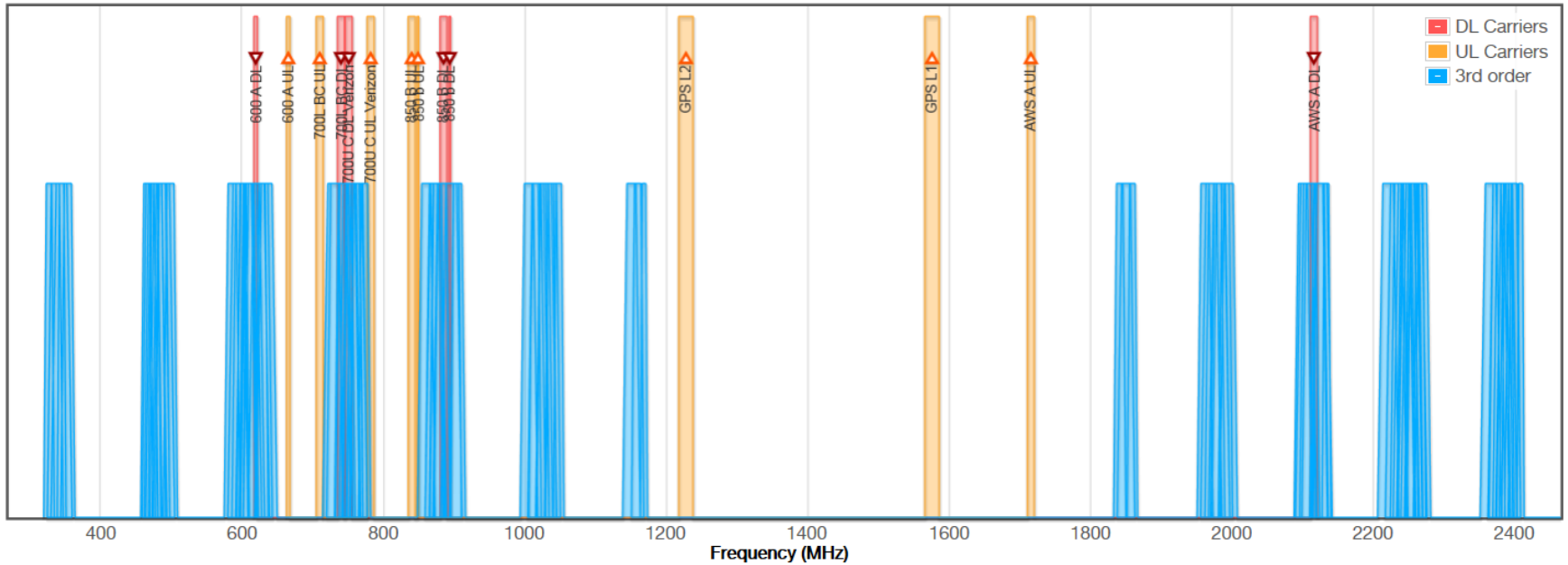
Band	Block	DL frequency (MHz)			Bandwidth	UL frequency (MHz)		
		Low	Middle	High	DL/UL (MHz)	Low	Middle	High
600 MHz	A	617	619.5	622	5	663	665.5	668
600 MHz	B	622	624.5	627	5	668	670.5	673
600 MHz	C	627	629.5	632	5	673	675.5	678
600 MHz	D	632	634.5	637	5	678	680.5	683
600 MHz	E	637	639.5	642	5	683	685.5	688
600 MHz	F	642	644.5	647	5	688	690.5	693
600 MHz	G	647	649.5	652	5	693	695.5	698
700L MHz	BC	734	740	746	10	704	710	716
700U MHz	C	746	751	756	10	777	782	787
AWS	A	2110	2115	2120	10	1710	1715	1720
850 MHz	B	880	885	890	10	835	840	845
850 MHz	b	891.5	893.88	894	2.5	846.5	848.88	849
GPS	L1	-	-	-	20.46	1565.2	1575.4	1585.7
GPS	L2	-	-	-	20.46	1217.4	1227.6	1237.8

Baseline
No 600 MHz Blocks



Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon

Baseline + 600 MHz A Block



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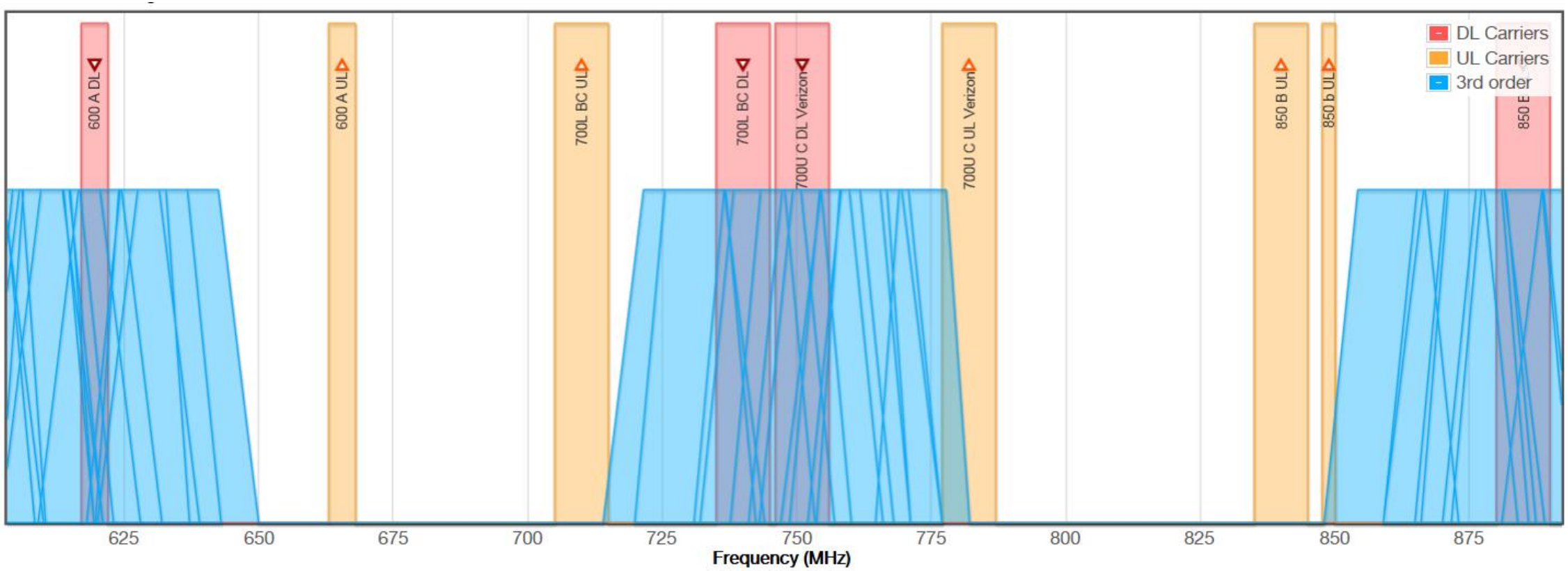
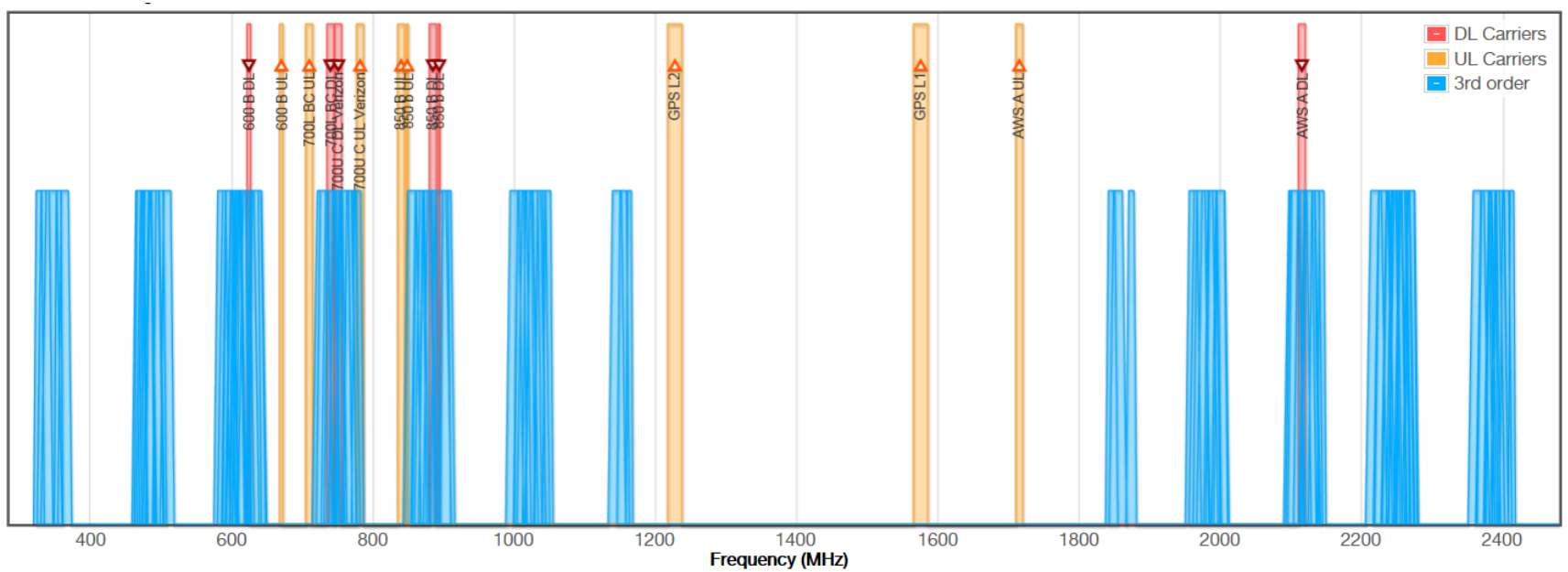
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×619.5 -1×740.0 +1×885.0	764.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 A DL 700L BC DL 850 B DL
3	+1×619.5 -1×740.0 +1×893.88	773.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 A DL 700L BC DL 850 b DL
3	-1×619.5 +2×740.0	860.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 A DL 700L BC DL

Baseline + 600 MHz A Block
Zoomed



Baseline + 600 MHz B Block



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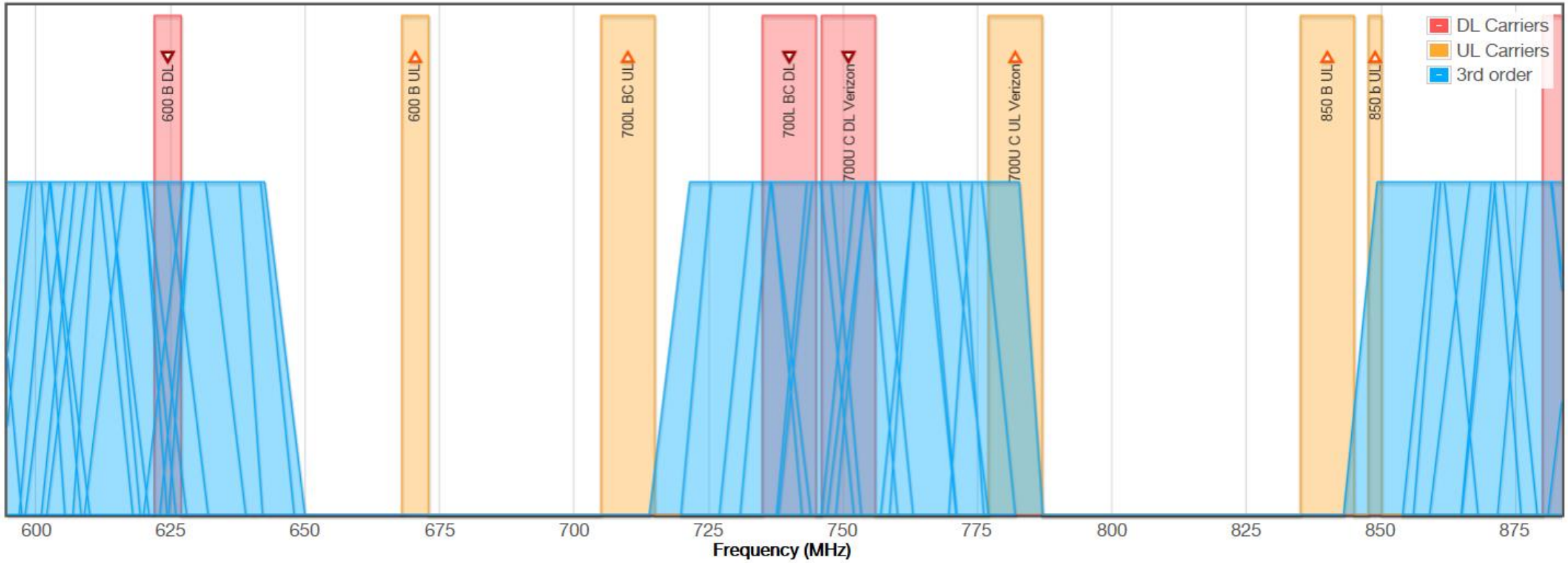
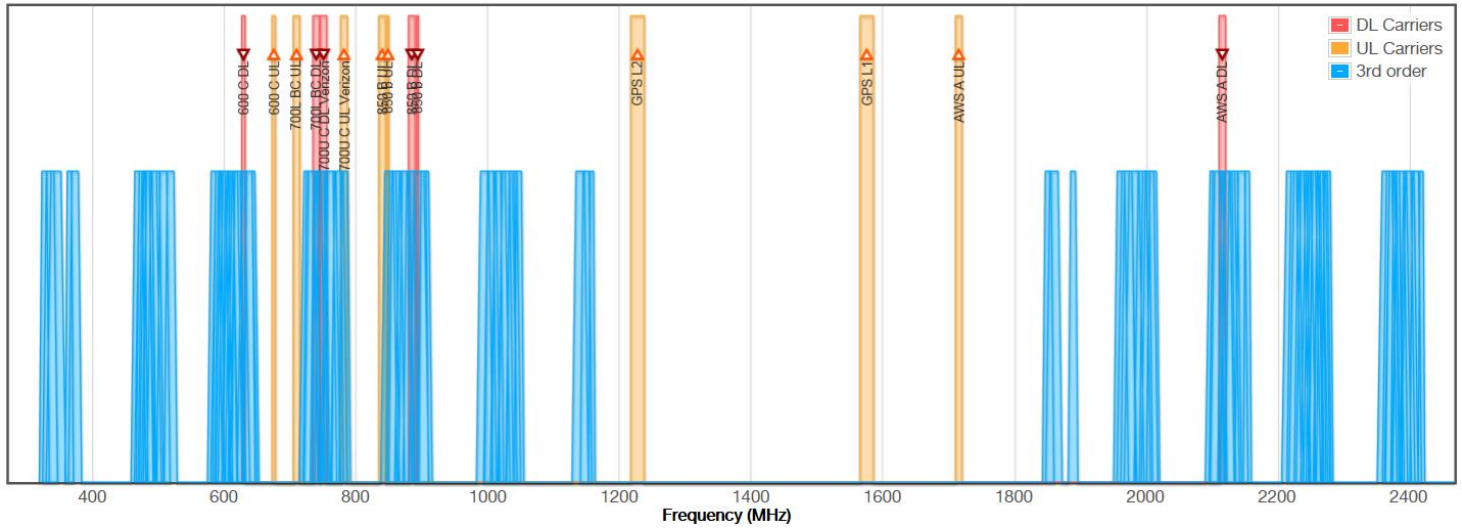
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×624.5 -1×740.0 +1×885.0	769.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 B DL 700L BC DL 850 B DL
3	+1×624.5 -1×740.0 +1×893.88	778.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 B DL 700L BC DL 850 b DL
3	-1×624.5 +2×740.0	855.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 B DL 700L BC DL

Baseline + 600 MHz B Block
Zoomed

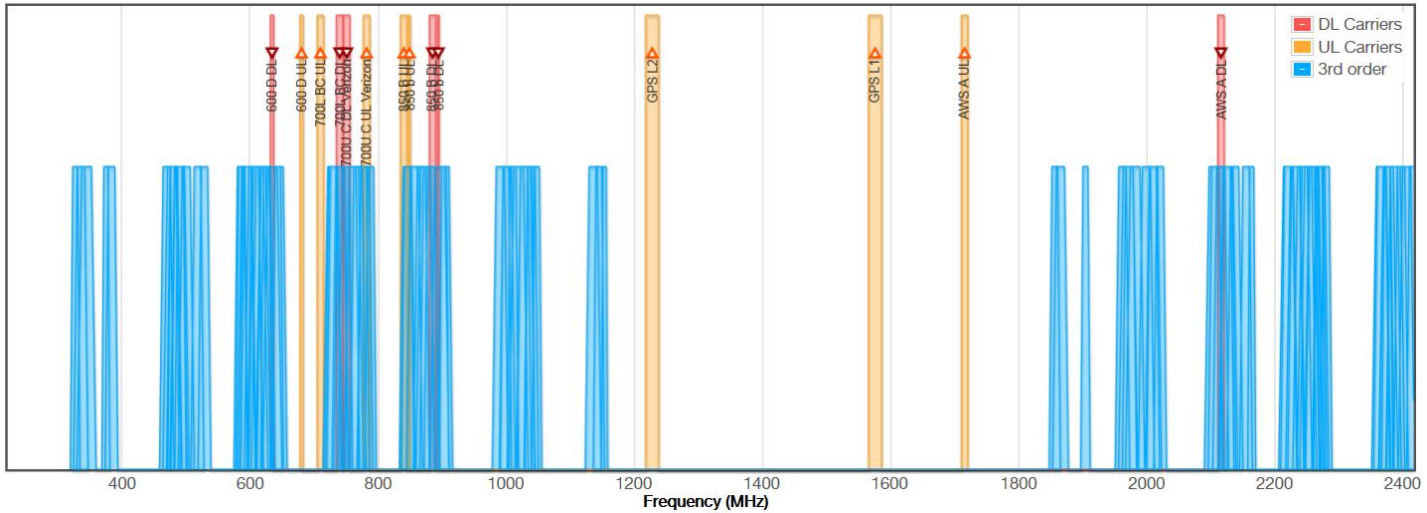


Baseline + 600 MHz C Block



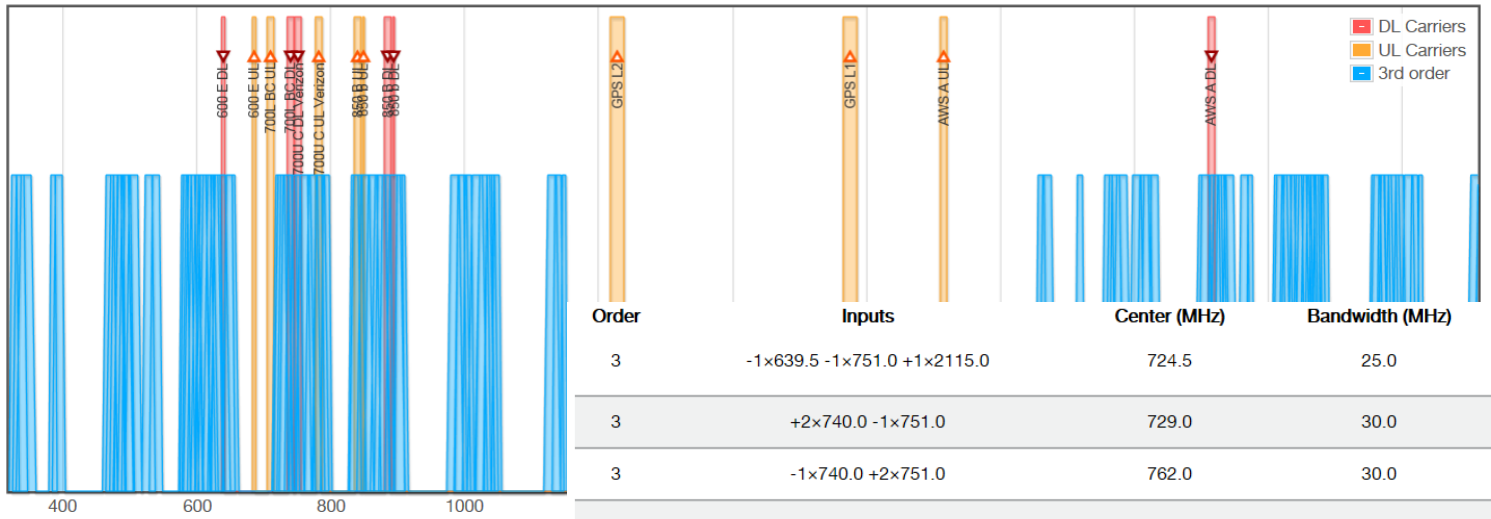
Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×629.5 -1×751.0 +1×893.88	772.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 C DL 700U C DL Verizon 850 b DL
3	+1×629.5 -1×740.0 +1×885.0	774.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 C DL 700L BC DL 850 B DL
3	+1×629.5 -1×740.0 +1×893.88	783.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 C DL 700L BC DL 850 b DL
3	-1×629.5 +2×740.0	850.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 C DL 700L BC DL
3	-2×629.5 +1×2115.0	856.0	20.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 C DL AWS A DL
3	-1×629.5 +1×740.0 +1×751.0	861.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 C DL 700L BC DL 700U C DL Verizon

Baseline + 600 MHz D Block



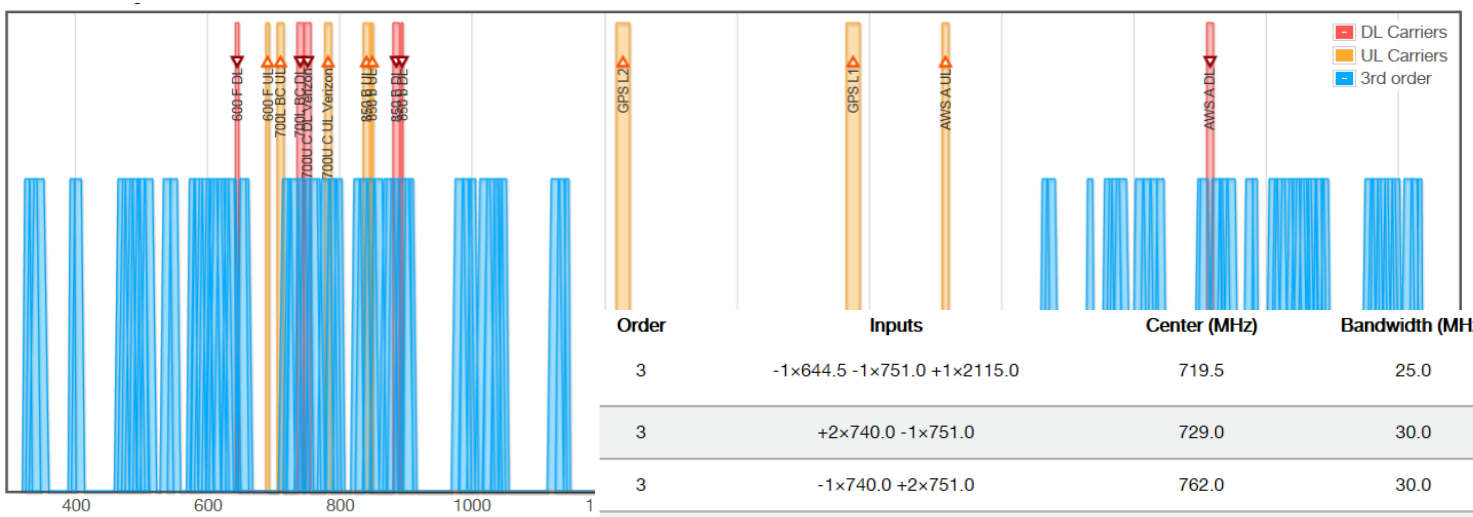
Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×634.5 -1×751.0 +1×885.0	768.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 D DL 700U C DL Verizon 850 B DL
3	+1×634.5 -1×751.0 +1×893.88	777.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 D DL 700U C DL Verizon 850 b DL
3	+1×634.5 -1×740.0 +1×885.0	779.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 D DL 700L BC DL 850 B DL
3	+1×634.5 -1×740.0 +1×893.88	788.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 D DL 700L BC DL 850 b DL
3	-1×634.5 +2×740.0	845.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 D DL 700L BC DL
3	-2×634.5 +1×2115.0	846.0	20.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 D DL AWS A DL
3	-1×634.5 +1×740.0 +1×751.0	856.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 D DL 700L BC DL 700U C DL Verizon

Baseline + 600 MHz E Block



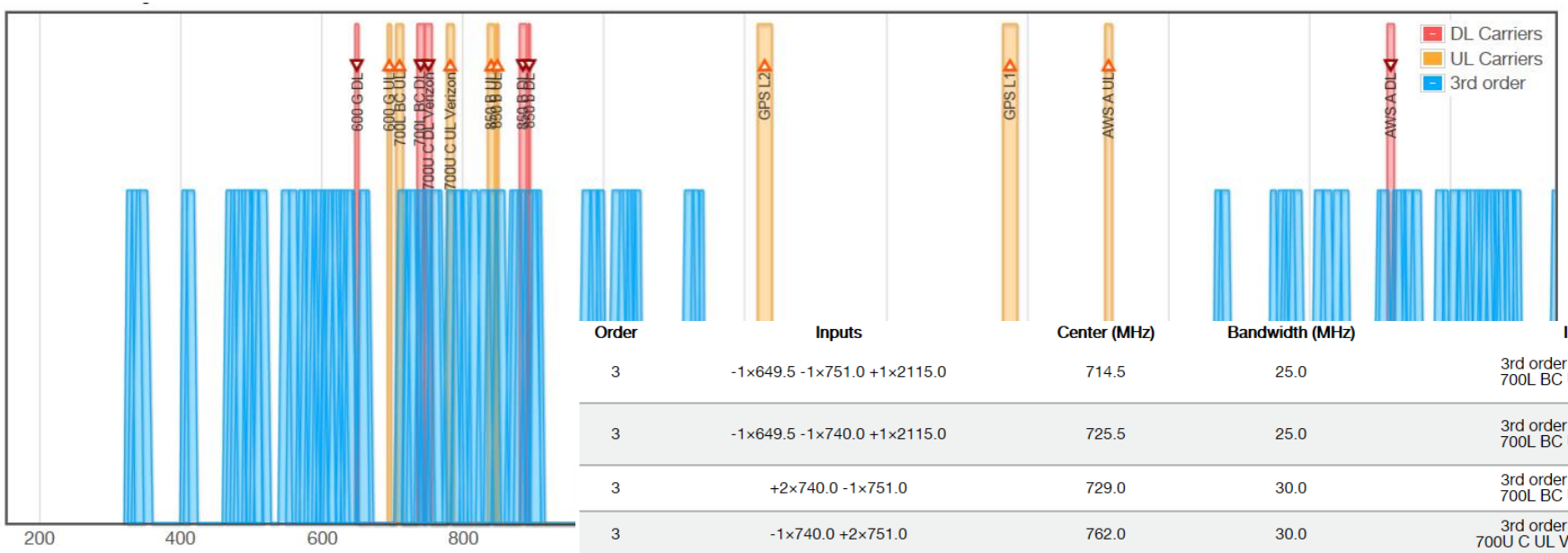
Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	-1×639.5 -1×751.0 +1×2115.0	724.5	25.0	3rd order PIM product in 700L BC UL (710.0 MHz)	600 E DL 700U C DL Verizon AWS A DL
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×639.5 -1×751.0 +1×885.0	773.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 E DL 700U C DL Verizon 850 B DL
3	+1×639.5 -1×751.0 +1×893.88	782.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 E DL 700U C DL Verizon 850 b DL
3	+1×639.5 -1×740.0 +1×885.0	784.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 E DL 700L BC DL 850 B DL
3	+1×639.5 -1×740.0 +1×893.88	793.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 E DL 700L BC DL 850 b DL
3	-2×639.5 +1×2115.0	836.0	20.0	3rd order PIM product in 850 B UL (840.0 MHz)	600 E DL AWS A DL
3	-1×639.5 +2×740.0	840.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 E DL 700L BC DL
3	-1×639.5 +1×740.0 +1×751.0	851.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 E DL 700L BC DL 700U C DL Verizon
3	-1×639.5 +2×751.0	862.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 E DL 700U C DL Verizon

Baseline + 600 MHz F Block



Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	-1×644.5 -1×751.0 +1×2115.0	719.5	25.0	3rd order PIM product in 700L BC UL (710.0 MHz)	600 F DL 700U C DL Verizon AWS A DL
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×644.5 -1×751.0 +1×885.0	778.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 F DL 700U C DL Verizon 850 B DL
3	+1×644.5 -1×751.0 +1×893.88	787.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 F DL 700U C DL Verizon 850 b DL
3	+1×644.5 -1×740.0 +1×885.0	789.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 F DL 700L BC DL 850 B DL
3	-2×644.5 +1×2115.0	826.0	20.0	3rd order PIM product in 850 B UL (840.0 MHz)	600 F DL AWS A DL
3	-1×644.5 +2×740.0	835.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 F DL 700L BC DL
3	-1×644.5 +1×740.0 +1×751.0	846.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 F DL 700L BC DL 700U C DL Verizon
3	-1×644.5 +2×751.0	857.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 F DL 700U C DL Verizon

Baseline + 600 MHz G Block



Order	Inputs	Center (MHz)	Bandwidth (MHz)	Impact	Contributors
3	-1×649.5 -1×751.0 +1×2115.0	714.5	25.0	3rd order PIM product in 700L BC UL (710.0 MHz)	600 G DL 700U C DL Verizon AWS A DL
3	-1×649.5 -1×740.0 +1×2115.0	725.5	25.0	3rd order PIM product in 700L BC UL (710.0 MHz)	600 G DL 700L BC DL AWS A DL
3	+2×740.0 -1×751.0	729.0	30.0	3rd order PIM product in 700L BC UL (710.0 MHz)	700L BC DL 700U C DL Verizon
3	-1×740.0 +2×751.0	762.0	30.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	700L BC DL 700U C DL Verizon
3	+1×649.5 -1×751.0 +1×885.0	783.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 G DL 700U C DL Verizon 850 B DL
3	+1×649.5 -1×751.0 +1×893.88	792.38	17.5	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 G DL 700U C DL Verizon 850 b DL
3	+1×649.5 -1×740.0 +1×885.0	794.5	25.0	3rd order PIM product in 700U C UL Verizon (782.0 MHz)	600 G DL 700L BC DL 850 B DL
3	-1×649.5 +2×740.0	830.5	25.0	3rd order PIM product in 850 B UL (840.0 MHz)	600 G DL 700L BC DL
3	-1×649.5 +1×740.0 +1×751.0	841.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 G DL 700L BC DL 700U C DL Verizon
3	-1×649.5 +2×751.0	852.5	25.0	3rd order PIM product in 850 b UL (848.88 MHz)	600 G DL 700U C DL Verizon