ANALOG DEVICES

AN-859 APPLICATION NOTE

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RF Port Impedance Data, Matching, and External Component Selection for the ADF7020-1, ADF7021, and ADF7021-N

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SCOPE OF THIS DOCUMENT

This application note describes the RF port impedance models of the power amplifier (PA) and low noise amplifier (LNA) of the ADF7020-1, ADF7021, and ADF7021-N. The port impedance values are listed for the range of frequencies over which the ADF7020-1, ADF7021, and ADF7021-N can operate with the external inductor VCO (130 MHz to 650 MHz). Matching circuits, loop filter components, and VCO tank inductor values are also provided for a range of frequency bands.

INTRODUCTION

The ADF7020-1, ADF7021, and ADF7021-N have two RF ports: an LNA input (RFIN/RFINB) and a PA output (RFOUT). The properties and function of these RF ports depend on the operating mode of the transceiver, that is, transmit (Tx) mode or receive (Rx) mode. The ports and the different states are shown in Table 1.

The need for complex broadband models is avoided by providing simple lumped-element models for each RF port. This simplification has the disadvantage of rendering the models valid only in a narrow frequency band. The ADF7020-1, ADF7021, and ADF7021-N port model has been extracted with an approach based on fixture modeling.

The ADF7020-1, ADF7021, and ADF7021-N feature an on-chip VCO with external tank inductor, which is used to set the RF frequency range. Information is provided on how to select this external inductor for the required operating band in the External VCO Inductor section.

Example loop filter and matching components are also given for various popular operating bands of the ADF7020-1, ADF7021, and ADF7021-N.

Table 1.

Port	State
PA Output (Single Ended, Ground Referred)	Tx: Optimum PA load impedance Rx: PA idle impedance
LNA Input (Single Ended, Ground Referred)	Tx: LNA idle impedance Rx: LNA input impedance (maximum gain)

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PA PORT IMPEDANCE

Tx MODE

The PA load impedance values have been optimized to yield an output power of 10 dBm at the lowest possible current consumption with a supply voltage of 3.0 V. This optimum PA load impedance ($Z_{OPTIMUM}$) is highlighted in Figure 1, which also shows the equivalent lumped-element circuit of this impedance. Note that when designing a matching network for the PA in transmit mode, model the PA as the conjugate of $Z_{OPTIMUM}$.

Table 2 lists optimum PA load impedance values in steps of 10 MHz over the frequency range of 160 MHz to 620 MHz.

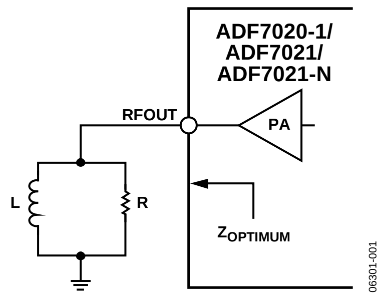

Figure 1. PA Optimum Load Impedance Definition in Transmit Mode and Lumped-Element Model

Table 2. PA Optimum Load Impedance in Transmit Mode

Frequency (MHz)	$Z_{OPTIMUM}$ (Ω)	R (Ω)	L (nH)
160	177.28 + 48.41i	190	694
170	174.66 + 48.73i	188	632
180	171.9 + 49.3i	186	574
190	169.02 + 50.06i	184	520
200	166.02 + 50.99i	182	471
210	162.93 + 52.03i	180	426
220	159.75 + 53.16i	177	386
230	156.5 + 54.33i	175	350
240	153.18 + 55.52i	173	317
250	149.82 + 56.71i	171	288
260	146.41 + 57.87i	169	262
270	142.99 + 58.97i	167	239
280	139.56 + 60.02i	165	219
290	136.14 + 60.98i	163	200
300	132.74 + 61.86i	162	184
310	129.37 + 62.65i	160	169
320	126.06 + 63.34i	158	156
330	122.81 + 63.93i	156	145
340	119.65 + 64.42i	154	134
350	116.62 + 64.81i	153	125
360	113.74 + 65.09i	151	117
370	111.04 + 65.28i	149	109
380	108.54 + 65.39i	148	103
390	106.26 + 65.42i	147	97
400	104.2 + 65.4i	145	92
410	102.4 + 65.32i	144	88
420	100.85 + 65.21i	143	84
430	99.58 + 65.08i	142	80
440	98.6 + 64.93i	141	78
450	97.92 + 64.77i	141	75
460	97.55 + 64.6i	140	73
470	97.5 + 64.43i	140	72
480	97.65 + 64.27i	140	71
490	97.86 + 64.13i	140	69
500	98 + 64.01i	140	68
510	97.93 + 63.94i	140	67
520	97.52 + 63.93i	139	65
530	96.64 + 63.98i	139	63
540	95.17 + 64.09i	138	61
550	93.02 + 64.21i	137	58
560	90.12 + 64.29i	136	54
570	86.55 + 64.23i	134	50
580	82.41 + 63.94i	132	47
590	77.84 + 63.34i	129	43
600	72.98 + 62.36i	126	39
610	67.97 + 60.98i	123	36
620	62.96 + 59.17i	119	32

Rx MODE

In receive mode, the parasitic capacitance of the PA port is of interest if a combined Rx/Tx match is being designed (as on the ADF7020-1, ADF7021, and ADF7021-N evaluation boards). Figure 2 shows the lumped-element model of the biased PA in Rx mode. Table 3 lists the optimum PA port impedance values in steps of 7 MHz for the frequency range of 150.5 MHz to 626.5 MHz.

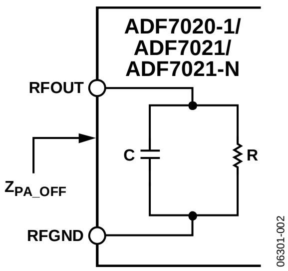

Figure 2. PA Port Impedance Definition in Receive Mode and Equivalent Lumped-Element Model

Table 3. PA Port Impedance in Receive Mode

Frequency (MHz)	Z_{PA_OFF} (Ω)	R (Ω)	C (pF)
150.5	25.71 – 265.48i	2767	3.95
157.5	29.31 – 274.14i	2593	3.64
164.5	25.86 – 281.78i	3096	3.40
171.5	19.65 – 281.12i	4041	3.29
178.5	18.42 – 273.92i	4092	3.24
185.5	18.27 – 266.72i	3912	3.20
192.5	18.46 – 259.52i	3667	3.17
199.5	18.63 – 252.47i	3440	3.14
206.5	18.57 – 245.7i	3269	3.12
213.5	18.36 – 239i	3130	3.10
220.5	17.82 – 232.79i	3059	3.08
227.5	17.53 – 226.9i	2954	3.06
234.5	19.48 – 219.07i	2483	3.07
241.5	19.35 – 215.94i	2429	3.03
248.5	17.82 – 210.02i	2493	3.03
255.5	17.39 – 203.99i	2410	3.03
262.5	17.46 – 198.72i	2279	3.03
269.5	17.4 – 193.91i	2178	3.02
276.5	17.08 – 189.36i	2116	3.02
283.5	16.66 – 184.97i	2070	3.01
290.5	16.35 – 180.56i	2010	3.01
297.5	16.23 – 176.12i	1927	3.01
304.5	16.26 – 171.96i	1835	3.01
311.5	16.11 – 167.8i	1764	3.02
318.5	15.85 – 163.58i	1704	3.03
325.5	15.63 – 159.8i	1649	3.03
332.5	15.43 – 156.21i	1597	3.03
339.5	15.17 – 152.5i	1548	3.04
346.5	14.94 – 148.94i	1500	3.05
353.5	14.75 – 145.61i	1452	3.06
360.5	14.52 – 142.4i	1411	3.07
367.5	14.04 – 139.02i	1391	3.08
374.5	13.89 – 136.06i	1347	3.09
381.5	13.69 – 133.17i	1309	3.10
388.5	13.48 – 130.32i	1273	3.11
395.5	13.31 – 127.51i	1235	3.12
402.5	13.1 – 124.8i	1202	3.13
409.5	12.86 – 122.21i	1174	3.15
416.5	12.66 – 119.72i	1145	3.16
423.5	12.51 – 117.27i	1112	3.17
430.5	12.43 – 115.08i	1078	3.18
437.5	12.24 – 112.91i	1054	3.18
444.5	12.01 – 110.79i	1034	3.19
451.5	11.78 – 108.67i	1014	3.21
458.5	11.58 – 106.55i	992	3.22
465.5	11.43 – 104.4i	965	3.24
472.5	11.25 – 102.48i	945	3.25
479.5	11.09 – 100.58i	923	3.26
486.5	10.91 – 98.72i	904	3.27
493.5	10.67 – 96.98i	892	3.29
500.5	10.48 – 95.16i	875	3.30
507.5	10.41 – 93.43i	849	3.32
514.5	10.23 – 91.75i	833	3.33
521.5	9.96 – 90.11i	825	3.35
528.5	9.86 – 88.47i	804	3.36
535.5	9.73 – 86.94i	787	3.38
542.5	9.59 – 85.46i	771	3.39
549.5	9.46 – 84.01i	756	3.40
556.5	9.32 – 82.61i	742	3.42
563.5	9.17 – 81.3i	730	3.43
570.5	9.02 – 79.91i	717	3.45
577.5	8.91 – 78.62i	703	3.46
584.5	8.8 – 77.41i	690	3.47
591.5	8.58 – 76.22i	686	3.49
598.5	8.43 – 74.96i	675	3.50
605.5	8.32 – 73.86i	664	3.51
612.5	8.19 – 72.78i	655	3.53
619.5	8.02 – 71.64i	648	3.54
626.5	7.92 – 70.53i	636	3.56

LNA PORT IMPEDANCE

Tx MODE

Figure 3 shows the lumped-element model of the LNA in transmit mode. This model reflects the measured port impedance values with an equivalent circuit of the lowest possible complexity.

When the ADF7020-1, ADF7021, and ADF7021-N are in transmit mode, the Tx/Rx switch is closed, providing a low impedance path (Z_B) between the differential inputs of the LNA (RFIN and RFINB). Z_A and Z_C represent the impedances between RFIN to GND and RFINB to GND, respectively, and they are equal. For the design of a matching network, the LNA input impedance can be modeled using the lumped-element model shown in Figure 3.

Table 4 lists the Z_A, Z_B, and Z_C impedances and their corresponding lumped-element values in 10 MHz steps for a frequency range of 100 MHz to 620 MHz.

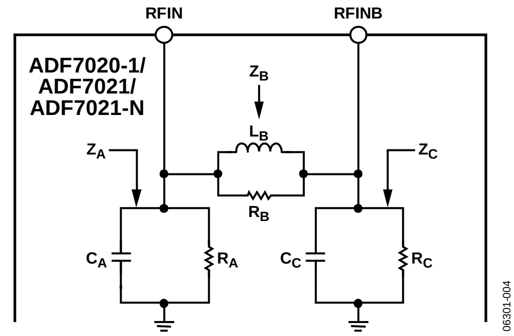

Figure 3. Lumped-Element Model of LNA in Transmit Mode

Table 4. Port Impedance and Lumped-Element Values for the LNA in Transmit Mode

Frequency (MHz)	Z_A (Ω)	R_A (Ω)	C_A (pF)	Z_B (Ω)	R_B (Ω)	L_B (nH)	Z_C (Ω)	R_C (Ω)	C_C (pF)
100	209.69 – 750.06i	2893	1.97	10.12 + 0.79i	10.2	207.6	209.69 – 750.06i	2893	1.97
110	192.68 – 701.23i	2745	1.92	10.12 + 0.86i	10.2	173.5	192.68 – 701.23i	2745	1.92
120	159.71 – 632.35i	2663	1.97	10.13 + 0.97i	10.2	141.6	159.71 – 632.35i	2663	1.97
130	141.32 – 596.57i	2660	1.94	10.12 + 1.07i	10.2	118.5	141.32 – 596.57i	2660	1.94
140	110.5 – 539.87i	2748	2.02	10.16 + 1.11i	10.3	107.0	110.5 – 539.87i	2748	2.02
150	100.4 – 500.12i	2592	2.04	10.16 + 1.2i	10.3	92.5	100.4 – 500.12i	2592	2.04
160	83.12 – 462.07i	2652	2.09	10.16 + 1.31i	10.3	79.7	83.12 – 462.07i	2652	2.09
170	76.19 – 423.43i	2429	2.14	10.16 + 1.4i	10.4	70.3	76.19 – 423.43i	2429	2.14
180	70.35 – 407.17i	2427	2.11	10.2 + 1.51i	10.4	62.3	70.35 – 407.17i	2427	2.11
190	55.83 – 378.53i	2622	2.17	10.16 + 1.63i	10.4	54.4	55.83 – 378.53i	2622	2.17
200	59.81 – 359.02i	2215	2.16	10.14 + 1.72i	10.4	48.9	59.81 – 359.02i	2215	2.16
210	57.75 – 338.81i	2045	2.17	10.14 + 1.82i	10.5	44.2	57.75 – 338.81i	2045	2.17
220	47.16 – 330.59i	2365	2.14	10.17 + 1.88i	10.5	41.2	47.16 – 330.59i	2365	2.14
230	47.58 – 308.71i	2051	2.19	10.14 + 1.99i	10.5	37.1	47.58 – 308.71i	2051	2.19
240	45.61 – 296.9i	1978	2.18	10.14 + 2.06i	10.6	34.5	45.61 – 296.9i	1978	2.18
250	39.44 – 274.86i	1955	2.27	10.14 + 2.15i	10.6	31.8	39.44 – 274.86i	1955	2.27
260	41.59 – 264.05i	1718	2.26	10.09 + 2.27i	10.6	28.8	41.59 – 264.05i	1718	2.26
270	35.5 – 253.72i	1849	2.28	10.11 + 2.44i	10.7	26.1	35.5 – 253.72i	1849	2.28
280	35.04 – 240.15i	1681	2.32	10.11 + 2.56i	10.8	24.1	35.04 – 240.15i	1681	2.32
290	31.94 – 234.19i	1749	2.30	10.13 + 2.75i	10.9	22.0	31.94 – 234.19i	1749	2.30
300	29.26 – 227.03i	1791	2.30	10.17 + 2.93i	11.0	20.3	29.26 – 227.03i	1791	2.30
310	30.13 – 217.74i	1604	2.31	10.22 + 3.07i	11.1	19.0	30.13 – 217.74i	1604	2.31
320	31.83 – 209.67i	1413	2.32	10.22 + 3.18i	11.2	17.9	31.83 – 209.67i	1413	2.32
330	31.13 – 202.45i	1348	2.33	10.27 + 3.33i	11.3	16.9	31.13 – 202.45i	1348	2.33
340	32.71 – 197.29i	1223	2.31	10.29 + 3.44i	11.4	16.0	32.71 – 197.29i	1223	2.31
350	31.84 – 193.62i	1209	2.29	10.3 + 3.5i	11.5	15.4	31.84 – 193.62i	1209	2.29
360	31.39 – 189.84i	1180	2.27	10.34 + 3.63i	11.6	14.6	31.39 – 189.84i	1180	2.27
370	28.33 – 181.71i	1194	2.31	10.37 + 3.75i	11.7	13.9	28.33 – 181.71i	1194	2.31
380	30.76 – 178.73i	1069	2.28	10.36 + 3.85i	11.8	13.3	30.76 – 178.73i	1069	2.28
390	30.87 – 173.95i	1011	2.27	10.38 + 3.97i	11.9	12.7	30.87 – 173.95i	1011	2.27

Frequency (MHz)	Z_A (Ω)	R_A (Ω)	C_A (pF)	Z_B (Ω)	R_B (Ω)	L_B (nH)	Z_C (Ω)	R_C (Ω)	C_C (pF)
400	32.18 – 170.85i	939	2.25	10.42 + 4.14i	12.1	12.1	32.18 – 170.85i	939	2.25
410	33.11 – 166.02i	866	2.25	10.47 + 4.2i	12.2	11.8	33.11 – 166.02i	866	2.25
420	30.47 – 159.59i	866	2.29	10.5 + 4.36i	12.3	11.2	30.47 – 159.59i	866	2.29
430	27.95 – 155.18i	890	2.31	10.54 + 4.5i	12.5	10.8	27.95 – 155.18i	890	2.31
440	30.2 – 150.2i	777	2.31	10.5 + 4.61i	12.5	10.3	30.2 – 150.2i	777	2.31
450	29.08 – 146.18i	764	2.33	10.47 + 4.71i	12.6	9.9	29.08 – 146.18i	764	2.33
460	29.13 – 142.38i	725	2.33	10.45 + 4.83i	12.7	9.5	29.13 – 142.38i	725	2.33
470	28.74 – 139.25i	703	2.33	10.42 + 4.92i	12.7	9.1	28.74 – 139.25i	703	2.33
480	29.71 – 137.39i	665	2.31	10.41 + 5.07i	12.9	8.8	29.71 – 137.39i	665	2.31
490	30.13 – 134.96i	635	2.29	10.44 + 5.26i	13.1	8.4	30.13 – 134.96i	635	2.29
500	31.09 – 131.09i	584	2.30	10.46 + 5.42i	13.3	8.2	31.09 – 131.09i	584	2.30
510	30.85 – 128.62i	567	2.29	10.43 + 5.62i	13.5	7.8	30.85 – 128.62i	567	2.29
520	31.41 – 125.89i	536	2.29	10.43 + 5.78i	13.6	7.5	31.41 – 125.89i	536	2.29
530	30.8 – 123.66i	527	2.29	10.41 + 5.91i	13.8	7.3	30.8 – 123.66i	527	2.29
540	31.27 – 121.49i	503	2.28	10.4 + 6.01i	13.9	7.1	31.27 – 121.49i	503	2.28
550	31.44 – 118.47i	478	2.28	10.39 + 6.14i	14.0	6.9	31.44 – 118.47i	478	2.28
560	31.61 – 117.03i	465	2.26	10.37 + 6.28i	14.2	6.7	31.61 – 117.03i	465	2.26
570	31 – 114.7i	455	2.27	10.37 + 6.45i	14.4	6.5	31 – 114.7i	455	2.27
580	31.16 – 111.91i	433	2.28	10.39 + 6.59i	14.6	6.3	31.16 – 111.91i	433	2.28
590	31.54 – 110.09i	416	2.26	10.38 + 6.76i	14.8	6.1	31.54 – 110.09i	416	2.26
600	31.3 – 107.92i	403	2.27	10.37 + 6.93i	15.0	6.0	31.3 – 107.92i	403	2.27
610	31.87 – 105.94i	384	2.26	10.36 + 7.08i	15.2	5.8	31.87 – 105.94i	384	2.26
620	31.62 – 103.66i	371	2.27	10.35 + 7.21i	15.4	5.7	31.62 – 103.66i	371	2.27

Rx MODE

For the design of a matching network in receive mode, the LNA input impedance can be modeled using the lumped-element model shown in Figure 4. Z_A and Z_C represent the impedances between RFIN to GND and RFINB to GND, respectively, and they are equal. Z_B represents the high impedance coupling path between RFIN and RFINB when the ADF7020-1, ADF7021, and ADF7021-N are in receive mode.

Table 5 lists the Z_A, Z_B, and Z_C impedances and their corresponding lumped-element values in 10 MHz steps for a frequency range of 80 MHz to 620 MHz.

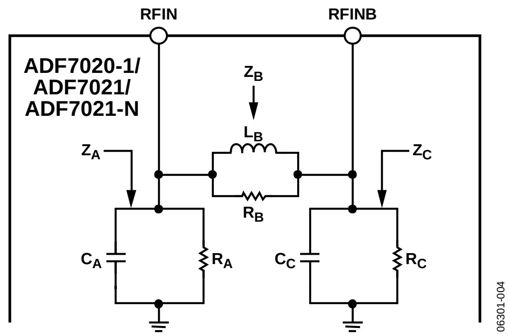

Figure 4. Lumped-Element Model of LNA in Receive Mode

Table 5. Port Impedance and Lumped-Element Values for the LNA in Receive Mode

Frequency (MHz)	Z_A (Ω)	R_A (Ω)	C_A (pF)	Z_B (Ω)	R_B (kΩ)	L_B (µH)	Z_C (Ω)	R_C (Ω)	C_C (pF)
80	283.6 – 195.34i	418	3.28	8752 + 45068i	240.8	93.0	283.6 – 195.34i	418	3.28
90	266.56 – 196.62i	412	3.17	8261 + 39759i	199.6	73.3	266.56 – 196.62i	412	3.17
100	255.86 – 197.01i	408	3.01	7723 + 35582i	171.7	59.3	255.86 – 197.01i	408	3.01
110	241.69 – 199.86i	407	2.94	7435 + 32166i	146.6	49.0	241.69 – 199.86i	407	2.94
120	235.11 – 196.3i	399	2.78	6943 + 29253i	130.2	41.0	235.11 – 196.3i	399	2.78
130	226.1 – 195.53i	395	2.68	6619 + 26815i	115.3	34.8	226.1 – 195.53i	395	2.68
140	214.85 – 196.68i	395	2.64	6435 + 24750i	101.6	30.0	214.85 – 196.68i	395	2.64
150	202.75 – 196.07i	392	2.62	6301 + 22917i	89.7	26.2	202.75 – 196.07i	392	2.62
160	190.63 – 193.43i	387	2.61	6179 + 21251i	79.3	22.9	190.63 – 193.43i	387	2.61
170	182.58 – 194.18i	389	2.56	6033 + 19870i	71.5	20.3	182.58 – 194.18i	389	2.56
180	175.45 – 187.62i	376	2.51	5829 + 18438i	64.2	17.9	175.45 – 187.62i	376	2.51
190	165.52 – 190.88i	386	2.50	5808 + 17361i	57.7	16.2	165.52 – 190.88i	386	2.50
200	157.68 – 187.19i	380	2.49	5695 + 16257i	52.1	14.5	157.68 – 187.19i	380	2.49
210	154.28 – 185.18i	377	2.42	5511 + 15322i	48.1	13.1	154.28 – 185.18i	377	2.42
220	147.36 – 182.92i	374	2.40	5423 + 14433i	43.8	11.9	147.36 – 182.92i	374	2.40
230	140.47 – 179.73i	370	2.39	5342 + 13593i	39.9	10.9	140.47 – 179.73i	370	2.39
240	135.28 – 176.8i	366	2.37	5238 + 12829i	36.7	9.9	135.28 – 176.8i	366	2.37
250	127.58 – 175.88i	370	2.37	5220 + 12157i	33.5	9.2	127.58 – 175.88i	370	2.37
260	122.84 – 172.06i	364	2.36	5122 + 11480i	30.9	8.4	122.84 – 172.06i	364	2.36
270	117.58 – 170.11i	364	2.34	5051 + 10882i	28.5	7.8	117.58 – 170.11i	364	2.34
280	112.3 – 167.68i	363	2.34	4989 + 10307i	26.3	7.2	112.3 – 167.68i	363	2.34
290	107.86 – 166.61i	365	2.32	4919 + 9803i	24.5	6.7	107.86 – 166.61i	365	2.32
300	103.61 – 163.58i	362	2.31	4840 + 9285i	22.7	6.3	103.61 – 163.58i	362	2.31
310	97.21 – 161.87i	367	2.33	4826 + 8817i	20.9	5.9	97.21 – 161.87i	367	2.33
320	94.36 – 158.11i	359	2.32	4722 + 8345i	19.5	5.5	94.36 – 158.11i	359	2.32
330	94.26 – 155.44i	351	2.27	4565 + 7939i	18.4	5.1	94.26 – 155.44i	351	2.27
340	90.14 – 152.23i	347	2.28	4501 + 7521i	17.1	4.8	90.14 – 152.23i	347	2.28
350	85.92 – 150.81i	351	2.28	4453 + 7163i	16.0	4.5	85.92 – 150.81i	351	2.28
360	83.5 – 148.35i	347	2.26	4361 + 6811i	15.0	4.2	83.5 – 148.35i	347	2.26
370	79.88 – 146.58i	349	2.26	4307 + 6482i	14.1	4.0	79.88 – 146.58i	349	2.26
380	76.06 – 144.22i	350	2.27	4262 + 6153i	13.1	3.8	76.06 – 144.22i	350	2.27
390	74.79 – 142.15i	345	2.25	4161 + 5864i	12.4	3.6	74.79 – 142.15i	345	2.25
400	73.08 – 138.83i	337	2.24	4064 + 5558i	11.7	3.4	73.08 – 138.83i	337	2.24
410	69.99 – 137.3i	339	2.24	4014 + 5298i	11.0	3.2	69.99 – 137.3i	339	2.24
420	68.84 – 135.07i	334	2.23	3917 + 5045i	10.4	3.1	68.84 – 135.07i	334	2.23
430	66.77 – 132.99i	332	2.22	3845 + 4803i	9.8	2.9	66.77 – 132.99i	332	2.22
440	63.82 – 130.69i	331	2.23	3795 + 4562i	9.3	2.8	63.82 – 130.69i	331	2.23
450	62.68 – 128.77i	327	2.22	3710 + 4350i	8.8	2.7	62.68 – 128.77i	327	2.22

Frequency (MHz)	Z_A (Ω)	R_A (Ω)	C_A (pF)	Z_B (Ω)	R_B (kΩ)	L_B (µH)	Z_C (Ω)	R_C (Ω)	C_C (pF)
460	61.25 – 127.17i	325	2.21	3636 + 4153i	8.4	2.5	61.25 – 127.17i	325	2.21
470	58.09 – 124.04i	323	2.24	3588 + 3917i	7.9	2.4	58.09 – 124.04i	323	2.24
480	57.24 – 121.85i	317	2.23	3499 + 3725i	7.5	2.3	57.24 – 121.85i	317	2.23
490	55.05 – 121.1i	321	2.22	3452 + 3562i	7.1	2.2	55.05 – 121.1i	321	2.22
500	53.91 – 119.38i	318	2.21	3378 + 3394i	6.8	2.2	53.91 – 119.38i	318	2.21
510	53.04 – 117.48i	313	2.21	3299 + 3233i	6.5	2.1	53.04 – 117.48i	313	2.21
520	52.45 – 115.4i	306	2.20	3216 + 3076i	6.2	2.0	52.45 – 115.4i	306	2.20
530	50.92 – 114.29i	307	2.19	3162 + 2937i	5.9	1.9	50.92 – 114.29i	307	2.19
540	49.99 – 112.68i	304	2.19	3092 + 2797i	5.6	1.8	49.99 – 112.68i	304	2.19
550	49.27 – 111.08i	300	2.18	3022 + 2666i	5.4	1.8	49.27 – 111.08i	300	2.18
560	48.21 – 109.71i	298	2.17	2961 + 2542i	5.1	1.7	48.21 – 109.71i	298	2.17
570	46.63 – 108.85i	301	2.17	2919 + 2428i	4.9	1.7	46.63 – 108.85i	301	2.17
580	45.71 – 107.46i	298	2.16	2860 + 2314i	4.7	1.6	45.71 – 107.46i	298	2.16
590	44.63 – 106.25i	298	2.16	2809 + 2207i	4.5	1.6	44.63 – 106.25i	298	2.16
600	43.79 – 104.88i	295	2.15	2751 + 2102i	4.4	1.5	43.79 – 104.88i	295	2.15
610	42.68 – 102.83i	290	2.16	2693 + 1984i	4.2	1.5	42.68 – 102.83i	290	2.16
620	41.44 – 100.73i	286	2.18	2638 + 1867i	4.0	1.4	41.44 – 100.73i	286	2.18

CHOOSING EXTERNAL COMPONENTS

MATCHING

Table 6 provides matching components at popular frequency bands for the ADF7020-1, ADF7021, and ADF7021-N evaluation boards (EVAL-ADF702xDBZx). Note that components L4, L5, and C35 act as a T-stage filter to suppress RF harmonics.

These matching components are valid only for the EVAL-ADF702XDBZx. If the PCB layout is changed, the matching must be redesigned using the PA and LNA impedance data provided in Table 2 to Table 5.

LOOP FILTER COMPONENTS

Table 7 provides loop filter components for various popular frequency bands. Each loop filter gives an open-loop bandwidth of about 60 kHz at the center frequency of the band, with a VCO_{ADJUST} of 1 and a charge pump current (I_{CP}) of 1.44 mA.

Note that because of the variation in VCO gain with the VCO tuning voltage, the loop filter bandwidth varies considerably across the band. ADI SRD Design Studio software (version 1.0 and up), which models this variation, is recommended for analyzing loop filter performance across a particular operating band (see Figure 5).

If the required operating band is wide the VCO_{ADJUST} and I_{CP} can be varied to keep the loop filter bandwidth somewhat constant across the band of interest. ADIsimPLL™ can be used for this analysis as well.

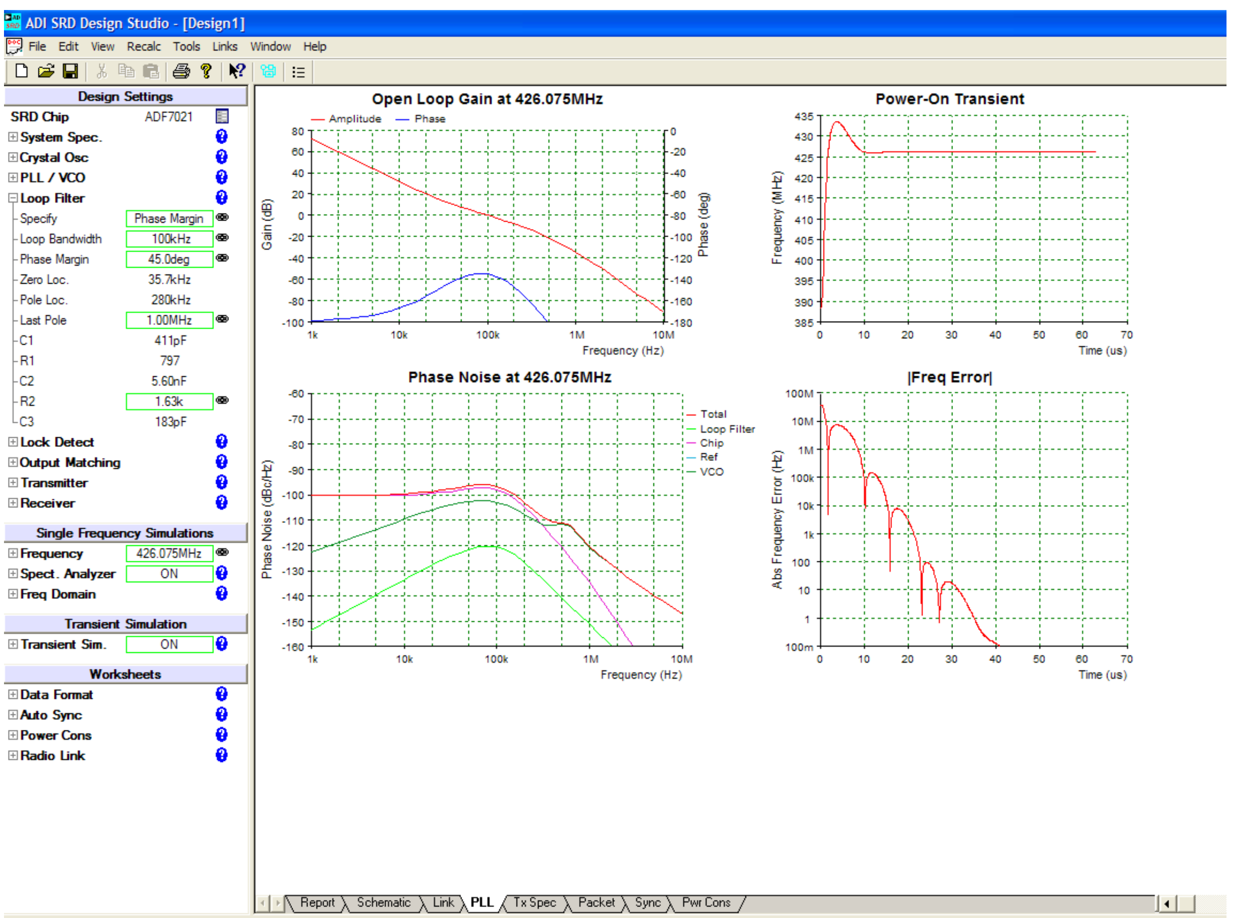

Figure 5. ADIsimPLL Software

EXTERNAL VCO INDUCTOR

The VCO inductor (L3) used with the ADF7020-1, ADF7021, and ADF7021-N sets the operating frequency of the VCO. Typically, a particular inductor value can get a ±6% range of the RF operating frequency. At 400 MHz, for example, an operating band of about ±24 MHz with a single inductor can be expected.

Figure 6 shows the operating frequency vs. the external inductor value (L_{EXT}) for the ADF7020-1, ADF7021, and ADF7021-N evaluation boards. It is very important to note that this is the external inductor value, not the total inductance as seen by the pins of the ADF7020-1, ADF7021, and ADF7021-N. Total inductance added by the traces on the EVAL-ADF702xDBZx has been measured as 2.66 nH.

ADIsimPLL (version 3.0 and up) can be used to automatically calculate the ideal value of the external inductance that centers the VCO tuning range. To view the results of this calculation, expand the **PLL/VCO** menu in the data panel on the left side of the screen (see Figure 5). The ideal external inductance to center the VCO tuning range is displayed under the **L(ext)** heading. Note that **L(ext)** in ADI SRD Design Studio is the total inductance, including track inductance.

To ensure operation over the required band, use of an inductor that centers the VCO operating range at the center of the required operating band is advised. The VCO operating point can be checked by measuring the VCO tuning voltage on the VCOIN pin of the ADF7020-1, ADF7021, and ADF7021-N. The VCO tuning range is 0.2 V to 2 V, meaning the VCO is centered when the tuning voltage is around 1.1 V.

Methods in which two or more inductors are used to extend the operating frequency range can be employed in applications where a single inductor does not provide the required operating range. Discontinuous ranges are also possible with these methods.

Table 6. EVAL-ADF702xDBZx Matching Components for Popular Frequency Bands

Frequency (MHz)	C1 (pF)	C2 (pF)	C3 (pF)	L1 (nH)	L2 (nH)	L4 (nH)	L5 (nH)	C35 (pF) (EVAL-ADF7020-1) C23 (pF) (EVAL-ADF7021/-N)
120 to 150	12	18	10	100	200	150	130	15
310 to 350	5.6	10	6.8	30	56	51	47	6.8
400 to 440	4.7	8.2	4.7	18	36	27	30	5.6
440 to 470	3.9	8.2	4.7	15	33	24	27	5.6
470 to 510	3.9	8.2	3.9	13	30	18	20	5.6

Table 7. EVAL-ADF702XDBZx Loop Filter Values for Popular Frequency Bands

Frequency (MHz)	Xtal (MHz)	PFD (MHz)	C16[1] C13[3] (pF)	C17 C12 (pF)	C18 C11 (pF)	R4 R1 (Ω)	R5 R2 (Ω)	Loop Filter BW (kHz)[2]
120 to 150	11.0592	5.5296	470	15000	1000	1000	390	60
310 to 350	9.8304	9.8304	330	10000	870	1500	680	60
400 to 440	11.0592	11.0592	390	15000	1000	1200	560	60
440 to 470	11.0592	11.0592	680	15000	1500	910	400	60
470 to 510	11.0592	11.0592	680	22000	1500	800	400	60

[1] ADF702-1.
[2] VCO_{ADJUST} =1, I_{CP} =1.44 mA. For ADF7021 and ADF7021-N a loop bandwidth of 90 kHz100 kHz is recommended.
[3] ADF7021-N.

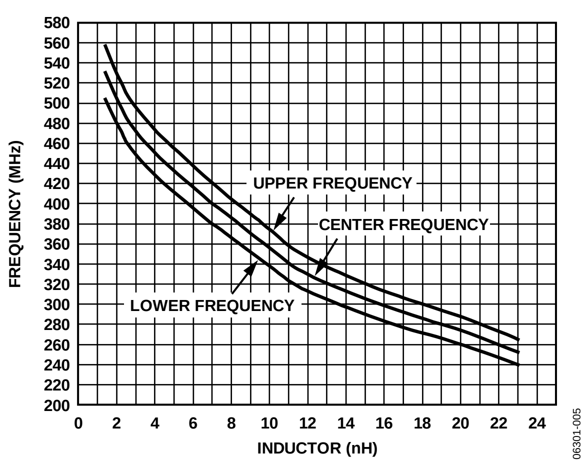

Figure 6. ADF7020-1, ADF7021, and ADF7021-N Frequency vs. L_{EXT} (L3) Using EVAL-ADF7020-1DBZx , EVAL-ADF7021DBZx, or EVAL-ADF7021-NDBZx Layout

NOTES

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