Study of RF VCOs and LNAs

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Striped Inductor VCO (APMC 2014, 2015, 2017, 2018)

In the high-frequency region (f>20 GHz), the skin effect appears, thus like a twig shape metal line is effective to reduce the skin effect, so, 2D-striped shape inductor was invented (Fig.1). The striped inductor is useful to reduce parasitic resistance and the corner frequency which occurs the skin effect will be higher than the conventional ones (Fig.2). Results the phase noise of VCO was approximately 3.6 dB improved at 23 and 40 GHz (Fig. 3). Also, 3D implementation of the striped inductor shows the thick metal is needed no longer (Fig. 4)

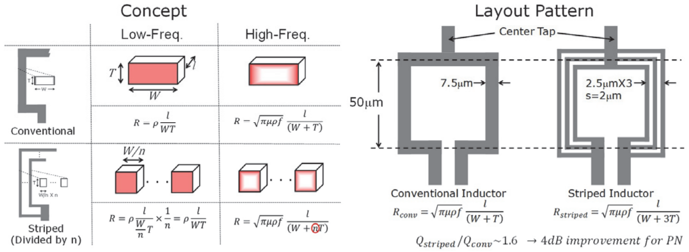

Fig.1 Concept of the striped inductor (left) and 2D implementation (right).

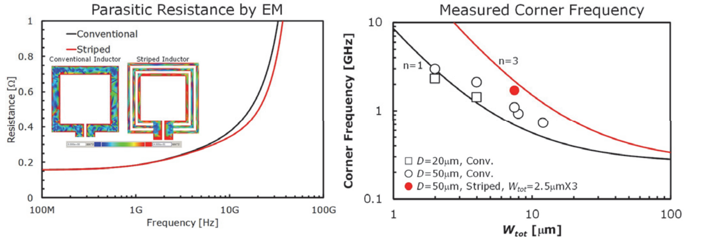

Fig.2 The parasitic resistance of conventional and striped inductor by EM simulation (left) and the corner frequency improvement (right).

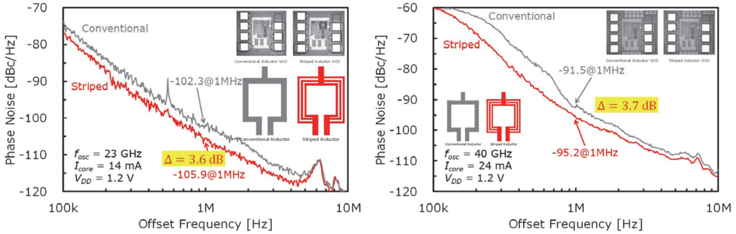

Fig.3 The measured phase noise of VCO was approximately 3.6 dB improved at 23 GHz (left) and 40 GHz (right).

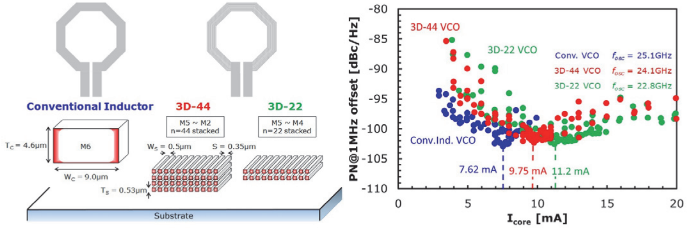

Fig.4 3D implementation of the striped inductor.

Concurrent Multi-band LNA

Concurrent Dual-band LNAs (APMC 2017, 2020)

To obtain wide bandwidth in the GHz frequency range, Carrier Aggregation is one of the most important technology. The concurrent multi-band LNA is an attractive solution to realize it. However, the circuit occupied area of the concurrent multi-band LNA is wider than mono-band LNA since it incorporated many on-chip inductors, so the balance between performance and occupied area is important. In our laboratory, several kinds of multi-band matching circuits were adopted for the conventional cascode amplifier to realize concurrent multi-band LNA, the detailed characteristics are shown below the table.

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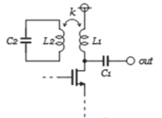
Input</td>
<td>
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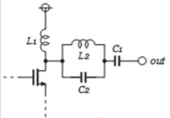
<td>
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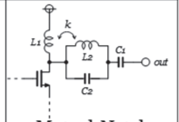
<td>
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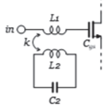
<td>
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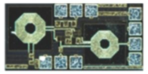
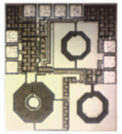
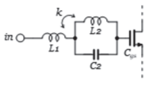
<td>[1]<table><tr><td></td><td>2.4G</td><td>5.2G</td></tr><tr><td>|s21|</td><td>18.1</td><td>9.9</td></tr><tr><td>NF</td><td>5.4</td><td>6.3</td></tr><tr><td>Area</td><td colspan="2">0.39mm²</td></tr></table></td>
<td>[2]<table><tr><td></td><td>1.7G</td><td>3.5G</td></tr><tr><td>|s_{21}|</td><td>11.2</td><td>10.6</td></tr><tr><td>NF</td><td>2.86</td><td>5.08</td></tr><tr><td>Area</td><td colspan="2">0.59mm²</td></tr></table></td>
<td>
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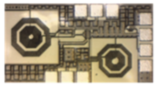
<td>[3]<table><tr><td></td><td>1.7G</td><td>3.5G</td></tr><tr><td>|s_{21}|</td><td>10.9</td><td>10.3</td></tr><tr><td>NF</td><td>2.64</td><td>2.99</td></tr><tr><td>Area</td><td colspan="2">0.47mm²</td></tr></table></td>
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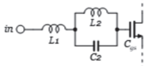
<td>
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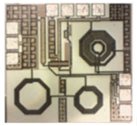
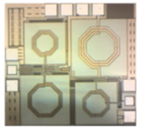
<td>[4]<table><tr><td></td><td>1.7G</td><td>3.5G</td></tr><tr><td>|s_{21}|</td><td>12.5</td><td>9.02</td></tr><tr><td>NF</td><td>1.91</td><td>3.25</td></tr><tr><td>Area</td><td colspan="2">0.62mm²</td></tr></table></td>
<td><table><tr><td></td><td>1.7G</td><td>3.5G</td></tr><tr><td>|s_{21}|</td><td>n.a.</td><td>n.a.</td></tr><tr><td>NF</td><td>n.a.</td><td>n.a.</td></tr><tr><td>Area</td><td colspan="2">0.66mm²</td></tr></table></td>
<td colspan="2">[1] T. Kitano, K. Komoku, T. Morishita, N. Itoh, “A CMOS LNA Equipped with Concurrent Dual-Band Matching Networks,” Proc. of the 2017 Asia-Pacific Microwave Conference, WE2-B, Kuala Lumpur, Nov. 2017.
[2] Y. Sawayama, T. Morishita, K. Komoku and N. Itoh, “Dual-Band Concurrent LNA with Low Gain Deviation and Low Noise Figure,” Proc. of the 2020 Asia-Pacific Microwave Conference, pp.1006-1008, Dec. 2020.
[3] Y. Sawayama, T. Morishita, K. Komoku, N. Itoh, "Study of Dual-Band Concurrent LNA Equipping Mutual Inductive Notch Filter Matching Circuit," IEICE Electronics Express, Vol. 18, No.5, 1-5, March 2021.
[4] Y. Sawayama, T. Morishita, K. Komoku and N. Itoh, “Dual-Band Concurrent Low Noise LNA,” Proc. of IEEE 2020 Radio-Frequency Integration Technology, pp.198-200, Hiroshima, Sept. 2020.</td>
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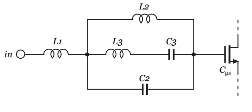
Concurrent Triple-band LNAs

Currently, we are focused on triple-band concurrent LNA in the same manner as dual-band one. The below figure is one example using a dual notch type matching circuit and its characteristics (simulation).

Input matching circuit



Output matching circuit