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## WIDEBAND ACTIVE INTEGRATED LOG PERIODIC ANTENNA

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**Introduction**

Active integrated antennas receive a great deal of attention because they can reduce the size, weight, cost of the transceiver system and minimizes the connection losses. Due to the mature technology of microwave integrated circuit (MIC) and monolithic microwave integrated circuit (MMIC), the active integrated antenna become an area of growing interest in recent years. Active integrated antennas have many potential application in wireless communications such as low cost and compact transceivers, detectors and sensors. Various antennas have been integrated into active devices that can be classified into oscillator type [1] , amplifier type [2,3]and frequency conversion type[4].

This paper describes four different configurations of integration active devices into log periodic antenna. The first configuration involves the integration of a single amplifier at the input feed line of a five element log periodic antenna (LPA). The second configuration involves the integration of an amplifier in the middle of the five elements LPA. The third configuration is the five element LPA with individual amplifiers in each element. The last configuration involves the integration of the individual amplifiers and filters with five element LPA in each element. The performance of these configurations have been investigated and compared in terms of bandwidth, gain relative to a passive LPA, cross polar isolation and beamwidth.

**Antenna Configuration**

**Integration of amplifier at the input feed of LPA**

This configuration is the simplest, where a single amplifier is integrated at the input of the LPA. The amplifier is biased with a voltage of 8.5 V with 40 mA biasing current. The dc blocking capacitor had to be put in front to block the dc from going into the measurement system. Figure 1(a) shows the configuration schematically, as used for circuit modeling. The layout of this configuration is shown in figure 1(b).
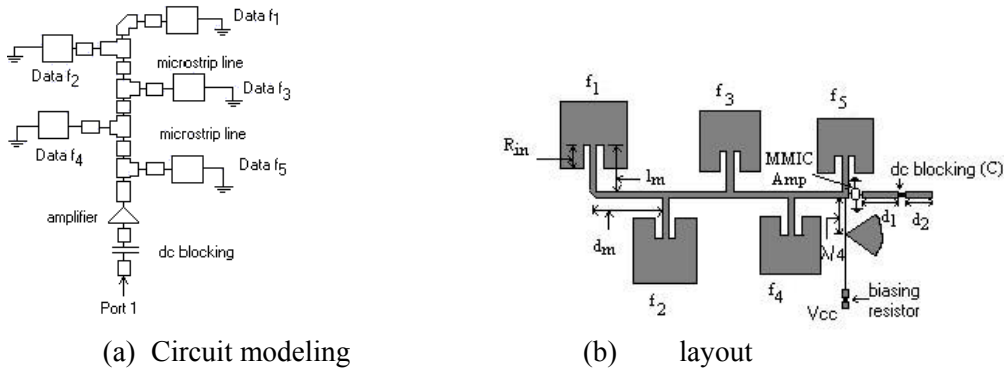
(a) Circuit modeling        (b)    layout

Figure 1: Circuit modeling and layout of the integration of the amplifier at the input feed

**Integration of amplifier in the middle of LPA**

The integration of an amplifier in the middle of a five element LPA is shown in figure 2. The amplifier is in the middle of the antenna between the third and fourth patches. In this design the first three elements can be considered as the passive design. After placing the amplifier at the input of the third patch, the fourth element is considered as an active element design. The procedure to design for the fourth element is similar to the design of the passive element. At frequency $f_4$ and at the point of attachment of the fourth patch element, the input impedance to the amplifier should be open circuit. Therefore the distance $d_2$ is adjusted to make that impedance as high as possible. The design process continues for the next element Figure 2 (a) shows the circuit modeling and figure 2 (b) shows the layout of the active antenna.
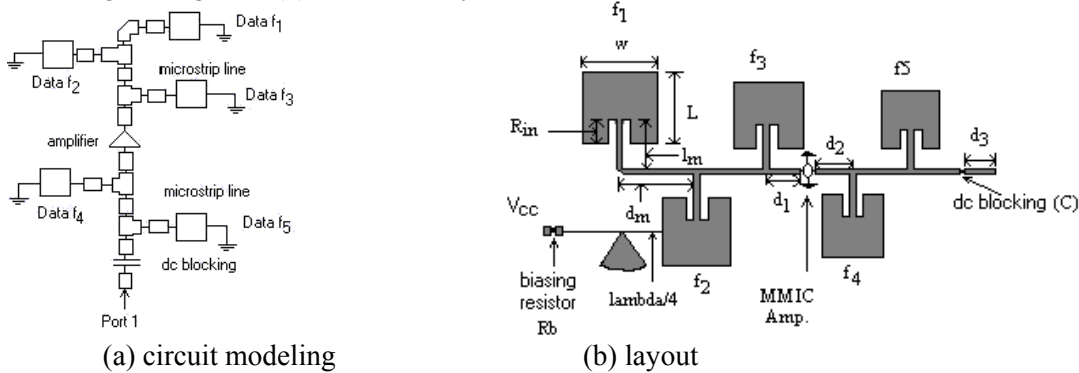


(a) circuit modeling        (b) layout

Figure 2: Circuit modeling and layout of integration of amplifier in the middle of LPA

**Integration of amplifier into each element of LPA**

The configuration of the active LPA with individual amplifiers is shown in figure 3. The amplifier is integrated at the inset feed of each antenna element. The biasing of the antenna is located at the centre of the non-radiating edge. At this edge the impedance is zero. The biasing voltage for this configuration is 8.5 V with the total current of 200 mA. This is because, the drive current for each amplifier is 40 mA. So for five elements the total current is 200 mA. The dc blocking capacitor had to be put in front of the feed network in order to block the dc voltage from reaching the network analyser. Figure 3(a) shows the circuit modeling and figure 3(b) shows the layout of the circuit.
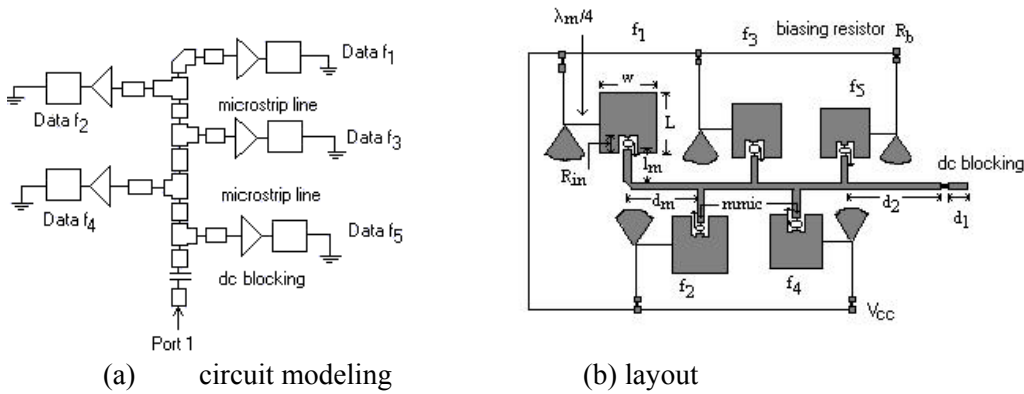
|  (a)        circuit modeling | (b) layout |

Figure 3: Circuit modeling and layout of integration of amplifier into each element of LPA

## Integration of amplifier and filters into each element of LPA

This configuration has been chosen in order to avoid the buffering effect on the log periodic active antenna when the amplifier is connected into the antenna without filter. The same procedure is applied when designing this circuit as was used for the passive LPA design. The band pass filter acts as a series LC filter tuned exactly to the frequency of the microstrip antenna. The effect of the filter will be to eliminate the buffering effect of the amplifier. The problem will arise when the tuning frequency is not the same as that of the patch antenna. Figure 4 shows the configuration of this active log periodic antenna.
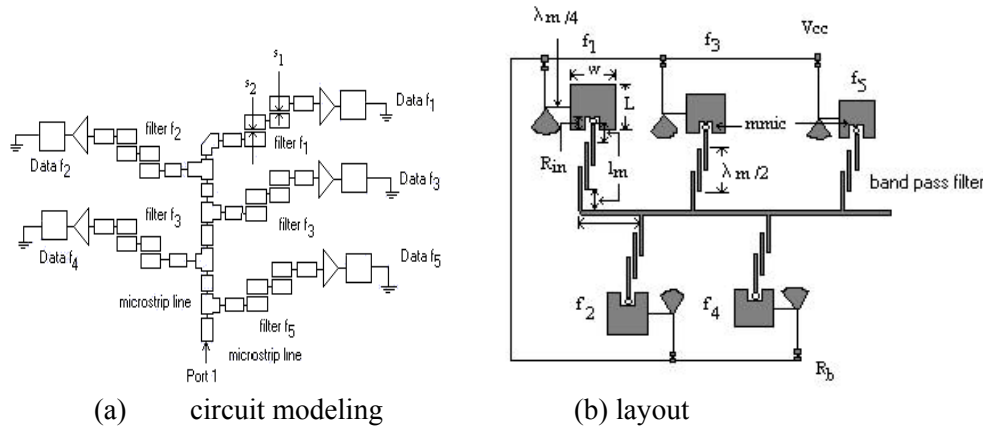


|  (a)        circuit modeling | (b) layout |

Figure 4 : Circuit modeling and layout integration of amplifier and filters into each element of LPA

## Result and Discussion

In the first configuration the bandwidth obtained is 37% from $S_{11}$ and 38% from $S_{21}$. The gain when compared with a passive antenna varies from 5 to 9 dB in the frequency range of 2.5 to 3.7 GHz. The cross-polar isolation is between 10 and 30 dB. The typical HPBW is $40^{\circ}$ for E plane and $60^{\circ}$ for H Plane.

The second configuration gives a better bandwidth. In this configuration the amplifier is connected in the middle of a log periodic antenna. The LPA has been divided into two sections, one with three elements and the other with two elements, with the amplifier in between. The BW from measurement of $S_{11}$ has a value of 27% but for the $S_{21}$ the BW is 55%. This configuration gives a better bandwidth from the $S_{21}$ measurement and the gain is increased by 10 dB at the

lower end compared to the passive antenna. The cross-polar isolation is between 10 and 25 dB. The HPBW is between $30^o$ and $70^o$ for E Plane. In the H Plane the HPBW is between $45^o$ and $70^o$.

In the third configuration, each antenna element has an individual amplifier embedded into the inset feed. The radiation pattern is very good at the centre frequency. It gives nearly 30 dB cross-polar isolation. The bandwidth for this configuration is 33% from $S_{11}$ and 42% from $S_{21}$. In this configuration the upper frequency limit of the antenna has been shifted upwards. The gain of this antenna is between –2 dB and 10 dB, relative to a passive antenna. The cross-polar isolation is 2 dB to 10 dB while the HPBW is between $30^o$ and $60^o$ for E Plane. The HPBW for H Plane is between $45^o$ and $60^o$.

The fourth configuration is the five element LPA with individual amplifiers and filters in each element. This configuration has been chosen in order to avoid the effect of buffering due to the amplifier. This had been expected to help in combining the antennas but the result is not good in terms of cross-polar, HPBW and the gain. This is because of the stray radiation and the insertion loss from the filter.

**Conclusion**


Integrating an amplifier in front of an array introduces signal gain without reducing bandwidth.

Integrating an amplifier in the middle of the feed line appears to offer some potential increase in the bandwidth and introduces additional gain for the array, but it also introduces a negative gain slope vs. frequency

Integrating individual amplifiers with each antenna element works well at the upper frequency limit but the buffering effect makes the gain response difficult to achieve. This configuration showed a positive gain slope vs. frequency. Further optimisations may be possible to achieve an overall flat gain response

Filters in front of each amplifier element potentially solve the buffering problem but are too lossy as a planar structure and too hard to tune to coincide with the antenna element frequency. Stray radiation from the filter degrades the antenna pattern.

**Reference**

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