REAL FREQUENCY METHOD APPLIED TO BROAD-BAND LASER COMMAND CIRCUIT DESIGN WITH LUMPED AND DISTRIBUTED ELEMENTS

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Abstract

In view to improve the LASER response which presents an electrooptic resonance, we propose an original method for LASER command circuit design. Our small signal application for remote antenna link used a differential amplifier comprising the matching network synthesis of active load as well as a one stage amplifier. This synthesis is carried out with lumped elements or transmission lines.

Introduction

A laser diode can be modulated from two differents way : the external and the internal modulation. The prospect given by the internal modulation is attractive for cost and compacity gain. In this way we present a new synthesis method for a LASER modulator using a differential amplifier structure. One application is the laser command circuit for remote antenna link where microwave signal received at antenna is transfert to the receiving station via an optic fiber link.

The major purpose in this work is to synthesize lossless matching networks between the transistors and the LASER diode which presents a very low impedance. Moreover, the frequency response of the laser diode presents an electrooptic resonance. So, the matching networks will be optimized to obtain a maximum flat optical power and a low input VSWR [1].

Before studying the command circuit structure and presenting the different results we describe briefly the formalism implemented in our method.

II - Network formalism

The real frequency method first introduced by CARLIN and YARMAN [2] was used to design broadband microwave amplifier [3]. Concerning the Laser command circuit, this method can also be applied. Indeed, the different lossless matching networks are caracterized by their scattering parameters using the Belevitch representation :

$$e_{11}(p) = \frac{h(p)}{g(p)} = \frac{h_0 + h_1 p + \ldots + h_n p^n}{g_0 + g_1 p + \ldots + g_n p^n}$$

$$e_{21}(p) = e_{12}(p) = \pm \frac{p^r}{g(p)} \qquad (1)$$

$$e_{22}(p) = -(-1)^r \frac{h(-p)}{g(p)}$$

where the polynomial h(p) is chosen as the unkwown and the polynomial g(p) is generated from the Hurwitz factorisation of

$$g(p).g(-p) = h(p).h(-p) + (-1)^r.p^{2r} \qquad (2)$$

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The synthesis is carried out using the Darlington procedure applied to the normalized e11(p). Moreover we can achieved the transmission lines synthesis using the Richards transformation.

III - Broadband LASER command circuit design

To avoid the LASER electrooptic resonance, we apply the real frequency method to a differential amplifier as command circuit. However, the electrooptic resonance of the LASER diode varies with the bias current.

III-1 - LASER diode model

The small signal model (Fig. 1) described by TUCKER and POPE [4], is carried out from the LASER rate equations. The model element values depends on the LASER bias current. The optical output power directly proportionnal to the voltage Vo is therefore proportionnal to the voltage V_2 at the r_x terminal (resistance which corresponds to the LASER cavity losses).

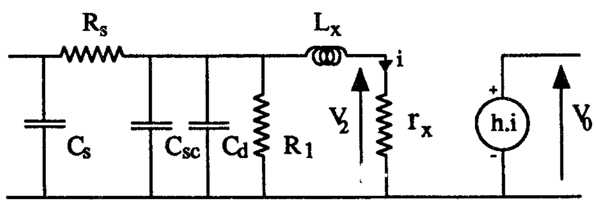

Fig. 1 : LASER diode small signal equivalent model

III-2 - Differential amplifier structure

The differential amplifier study is divided into two distinct operating mods because of the PP' symetry existence (Fig. 2). Then, it appears two different goals in this structure study. We have to obtain a voltage gain constant in a frequency range for the odd mod, and to reject strongly the even mod.

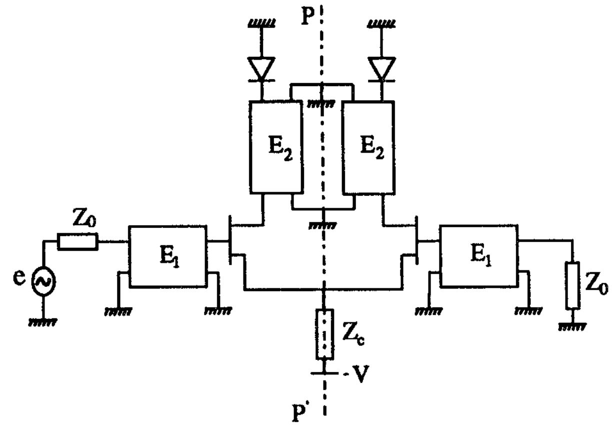

Fig. 2 : Differential amplifier global structure

* The odd mod

Fig. 3 shows the odd mod structure equivalent to a one stage cascaded circuit, in which we have introduced two equalizers E_1 et E_2. Using the real frequency method we optimize simultaneously the voltage gain and the input VSWR. In order to design a wide band LASER command circuit, it is appropriate to use a transistor with resistive feedback networks.

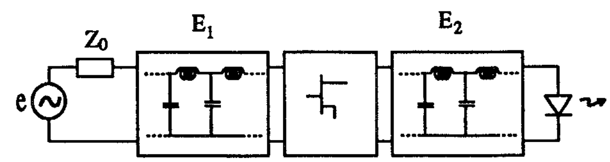

Fig. 3 : Odd mode structure represented with L-C lumped matching networks

* The even mod

The active load (Z_c) synthesis (Fig 4) is performed in the goal to obtain the maximum even mod rejection (S_{21e}#0). When this rejection is strong enough, the differential amplifier and the odd mod operating are equivalent.

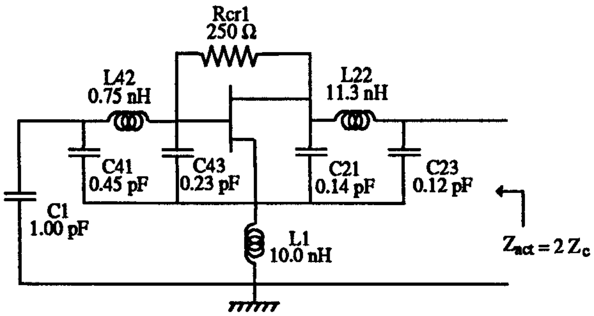

Fig. 4 : One example of an active load synthesis comprising two equalizers

IV. Results with lumped and distributed elements

The simulations and the results concerning an application for remote antenna link in the 10.7 - 14.5 GHz frequency range, have been done with a Fujitsu FHX04X HEMT transistor. The odd mod distributed synthesis illustrated on Fig. 5 where all elements are technically realisable, gives frequency responses shown on Fig. 6 and Fig. 7.

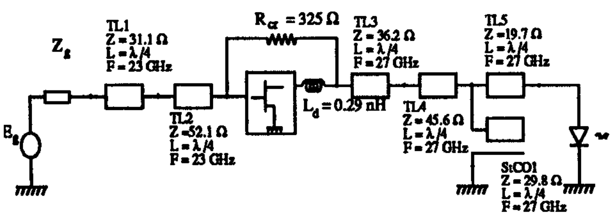

Fig. 5 : Odd mod synthesis where matching networks contain two and four elements

We compare (Fig. 6) the LASER diode response without matching networks with the LASER command circuit. We also observe for a 100 mA bias current the small signal output optical power which is higher than the LASER diode response and presents a good flatness (± 0,25 mW) across the bandwith. The input VSWR (Fig. 7) is lower than 2.

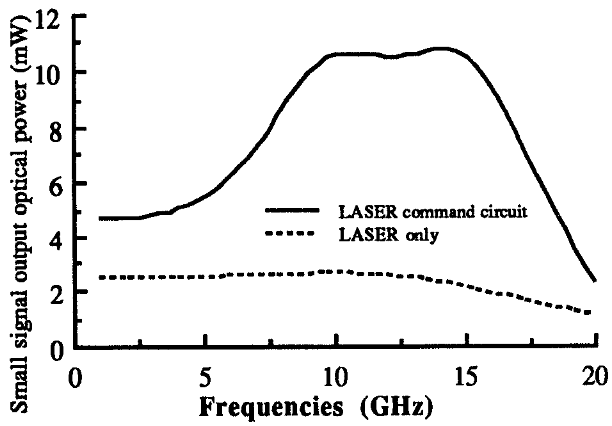

Fig. 6 : Comparison between the LASER frequency response and the Laser command circuit

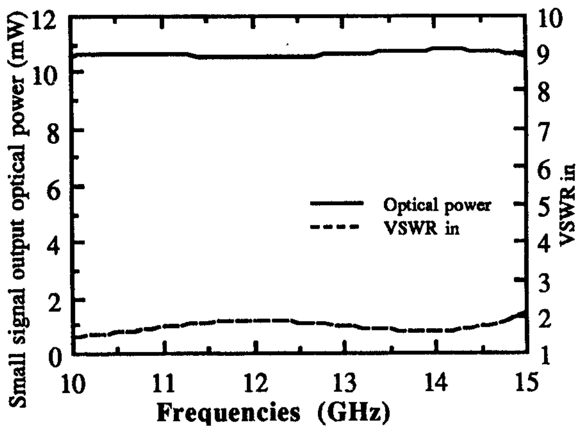

Fig. 7 : Frequency output optical power and VSWR responses in the bandwidth

Fig. 8 shown the even mod frequency response given by the active load with lumped element. This active load synthesis contains two matching networks and the bias elements (L_1, C_1), we can consider that the differential amplifier responses has the same form than the odd mod response as the rejection is lower than - 30 dB across the bandwidth.

It appears a difference of 6 dB between the differential amplifier and the odd mod response ; this is due to the relation between the transmission scattering parameters of the even and odd mods and the global one:

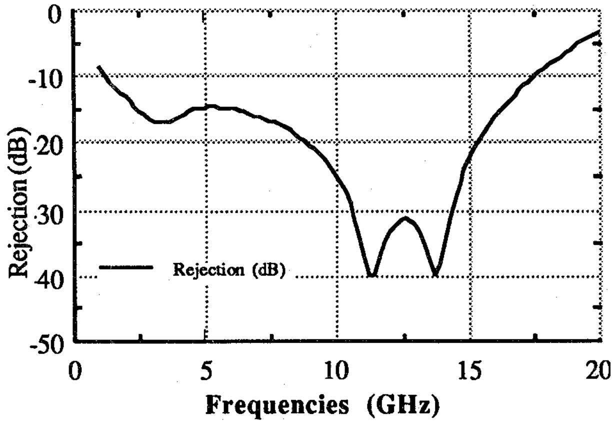

Fig. 8 : Even mod rejection given for the active load described on Fig. 4

V - Conclusion

We have shown that microwave matching technique, such as the real frequency method, can improve the LASER diode response. The LASER command circuit for remote antenna link increases the small signal output optical power and also the LASER diode bandwidth. Note that the method gives good results for a synthesis with lumped elements and transmission lines.

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