MICROWAVE ENGINEERING EUROPE

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2.5 Gbit/s optical heterodyne receiver using MMICs

In this paper, a balanced optical front-end and IF module for a coherent heterodyne optical receiver are presented using both full custom and commercial MMICs. Developed at ETSI Telecomunicación, Madrid, the authors are B Pablo Dorta, José I Alonso, Félix Perez from ETSI, and Juan A Casao now at Centro Politécnico Superior from Zaragoza.

Since optical fibre transmission systems have found widespread commercial application in communication networks, interest has increased for more advanced type of optical systems, using coherent modulation and heterodyne detection methods [1],[2],[3]. The coherent optical communication technologies, such as a continuous phase frequency shift keying (CPFSK), have been intensively studied with a view to future generation, long distance, high-data-rate optical communications systems [4],[5],[6]. These systems have proven to be very competitive vis-a-vis the direct detection systems in terms of bandwidth and sensitivity [7]. In optical coherent systems, the bandwidth has to be a couple of times larger than the transmission bit rate because the IF center frequency is typically set about twice as high as the bite rate . Yet, for practical use in this field, the CPFSK transmission systems should be stable, compact, economical, repetitive and has high reliability. To attain such demands, the monolithic microwave integrated circuits (MMICs) appear as the better choice. On the other hand, the stage of maturity this technology have now reached allows to find complex multi-function MMICs available commercially [8].

This paper describes the design and construction of a coherent heterodyne optical receiver that can be used in these optical systems. This receiver consist of optical balanced front-end and a IF module. The optical balanced front-end is based on two commercially available p-i-n photodiodes from Lasertron and a full custom designed GaAs MESFET MMIC using the commercial F20 GaAs process, from GEC-Marconi [9]. The main characteristic of IF module is its high gain and low ripple. The IF module consist of three amplifier stages, a variable attenuator, a pass-band filter and a broadband coupler. The amplifier stages and the variable attenuator are realized with MMICs chips from Triquint Semiconductors and NEC. The filter and coupler have been constructed in hybrid technology.

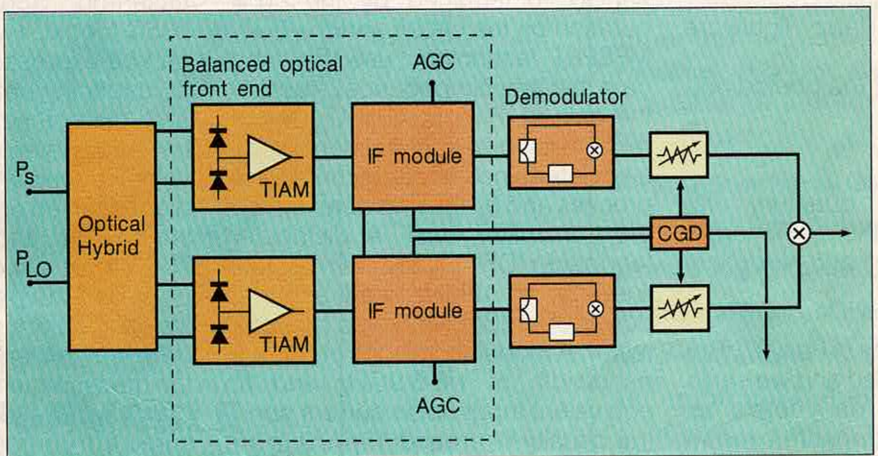

Figure 1: Block scheme of optical receiver.

System requirements

The balanced optical front-end and the IF module were designed and built up for use in a 2.5 Gbit/s CPFSK coherent transmission system with balanced polarization diversity reception [10],[11]. Figure 1 shows the block scheme of optical receiver developed. This kind of optical receiver is useful in polarization modulated systems in which, since the information is coded into polarization changes, it is necessary to estimate the polarization state of the received field. The main difficulties in realizing such an optical front-end is to realize a perfectly balanced hybrid and four photodiodes, each pair with the corresponding balanced electrical front-end, rigorously with the same characteristics. Two balanced optical front-ends have been constructed, obtaining a matching between their responses lower than 0.5 dB. On the other hand, because of the input power in each branch is depend on the polarization of the received field, the control gain diversity (CGD) circuit control the gain of each variable attenuator in order that the optical instantaneous polarization will be maximum at the output. Moreover, the IF module has an automatic gain control (AGC) which provide constant power at the output of IF module, independently of the attenuation level in the fibre and the state of the optical polarization.

The system requirements that must be specified for the two subsystems are: the transimpedance and the equivalent input noise density of the optical front-end and the gain of IF module.

With reference to figure 1, the output power at IF module can be expressed as follows:

$$P_{out}(dBm)=P_s(dBm)-10\log(Z_0/2)+R_T(dB\Omega) -10\log R_0+P_L(dBm)-30dB \quad (1)$$

or

$$R_T(dB\Omega)=P_{out}(dBm)-P_s(dBm)+10\log(Z_0/2) +10\log R_0-P_L(dBm)+30dB \quad (2)$$

where:

P_{out} = Electrical output power of IF module
P_s = Receiver sensitivity
Z_o = Load resistance (=normally 50)