GaAs MONOLITHIC TRANSIMPEDANCE AMPLIFIER FAMILY (TB 40) DEVELOPED AT R&D CENTER OF TELEBRÁS

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Abstract

The paper presents the development of MMIC GaAs transimpedance amplifiers for optical systems, carried out at R&D Center of Telebrás together with University of Rome through the ITU/UNDP project. A transimpedance family was designed, in order to fulfill the needs for optical systems at different bit rates. A set of simulated characteristics of the components are presented. The results of the circuit at 2.5 GHz are showed..

Introduction

Considering the existing planes for massive introduction of optical networks into large brazilian urbarn areas and for the next extention of optical links of very large capacity to the long distance intercommunication into and outside the Brazil, the R&D Center of Telebrás (Brazilian Telecommunication Holding Company) is working on optical fiber systems with rates compatible with those of SONET and SDH applications.

The development of the pre-amplifiers for detection and regeneration using GaAs technology, is part of this programme and is going on at the High Frequency Group of the Microelectronics Division of the R&D Center. The University of Rome is participating on this development through consultancies for the International Telecommunication Union/ United Nations Development Programme (ITU / UNDP - Geneva).

The components were designed with electrical characteristics in agreement with the international standards of CCITT [1], in order to work in optical systems operating at different bit rates, as showed in the following table.

Table 1: Application

Maximum Bit Rate	Application
55.84 Mb/s	SONET/OC-1
155.52 Mb/s	SDH/STM-1, SONET/OC-3
622.08 Mb/s	SDH/STM-4, SONET/OC-12
2488.32 Mb/s	SDH/STM-16, SONET/OC-48

It is important to emphasize that this is the first experience in GaAs integrated circuits in Brazil and problably the first one in South America.

Design Aspects

The four components have basically the same topology, with three stage amplification as showed in the fig. 1.

The first one, the most critical, was configurated in a cascode approach using a feedback resistor. The cascode configuration presents a single inverting (common source) - non inverting (common gate) two stage amplifier. Due to the low input resistance of the cascaded common gate stage, the Miller capacitance can be reduced assuring an enlargement of the bandwidth. As it is easy to demonstrate, with the proper choice of gate width of the involved MESFET of this cascode structure, is possible to obtain a gain-bandwith product significantly high. The proper paralell feedback contributes to extend the overall bandwidth, due to the reduction of the input RC constant.[2] [3] [4] [5] [6]

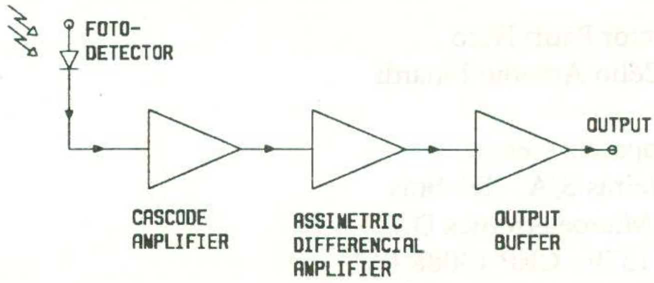

Figure 1 - Transimpedance Circuit Topology

The second stage was choosen as an assymetrical differential amplifier corresponding to a voltage amplifier. The section consists of a common drain MESFET followed by a common gate MESFET. This stage provides gain without affecting significantly the bandwidth of the whole amplifier. To obtain this result, this stage was designed to present no capacitive loading to the first stage. [6] [7]

The last one is a double source follower to match the transimpedance amplifier output to a 50 ohms environment. A MESFET with gm = 20 mS assures the proper matching.[2] [3] [4] [5] [6] [7]

Main Targets

Using the topology previously mentioned, the components were designed based on the GEC Marconi Materials and Technology Limited (GMMTL) foundry half micron F20 process.

In the design some additional requirements were considered, like: operation with high capacitance receiving photodiode (receiver cost reduction), low power consumption and small chip size (component cost reduction).

The table 2 presents the simulated results and some other aspects of the transimpedance family.

Once the circuits can operate with high capacitance photodiode, it will allow us to develop receivers with the photodetectors manufactured at the R&D Center of Telebrás.

The 2.5 GHz Tramsimpedance Amplifier

In this section will be put into evidence only the performance of the 2.5 Ghz amplifier, the most important of the family. All results of this first transimpedance version have comments, once improvements in the design are being made for the next run.

In the fig. 2 and 3 is shown the schematic and the lay-out of the 2.5 GHz amplifier respectively. The input/output of the circuits are CPW structutres in order to make it easy the cha racterization with the on-wafer microprobe.

An accurate series of measurements has been performed in the 2.5 Ghz amplifier without the photodiode.

In the fig. 4 and 5 the S_{21} and S_{11} results of the components are plotted.

The bandwidth obtained is 2.2 GHz. This result is due to a change done in the lay-out of the first transistor (T1) of the cascode structure, which added a 0.06 pF capacitance between drain and gate. The gate connections overlayed by the source connection, with polyimide between them. If this capacitance is included in the schematic the simulated results are in agreement with the measured.

Table 2: Characteristics of the Transimpedance Family

Characteristics	TB 40A	TB 40B	TB 40C	TB 40D	Units
Transimpedance RL= 50 ohms	87.3	78.5	81.5	66.0	dBohm
3 db Bandwidth C = 0 pF	177	550	1400	3450	MHz
3 dB Bandwidth C = 0.4 pF	67	170	580	2250	MHz
Output Impedance	50	50	50	50	ohms
Optical Overload	-3.0	-3.0	-20.0	-11.0	dBm
Automatic Gain Control Block	yes	yes	no	no	-
Negative Bias Vss	-5.2	-5.2	-5.2	-5.2	Volts
Positive Bias Vdd	5.0	5.0	5.0	5.0	Volts
Maximum Power Consumption	510	500	350	450	mW
Chip Area	1.23	1.23	1.10	1.10	mm sq.

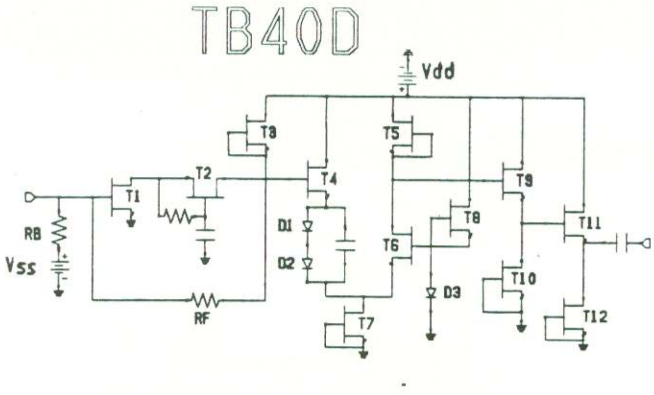

Figure 2 - Transimpedance Schematic

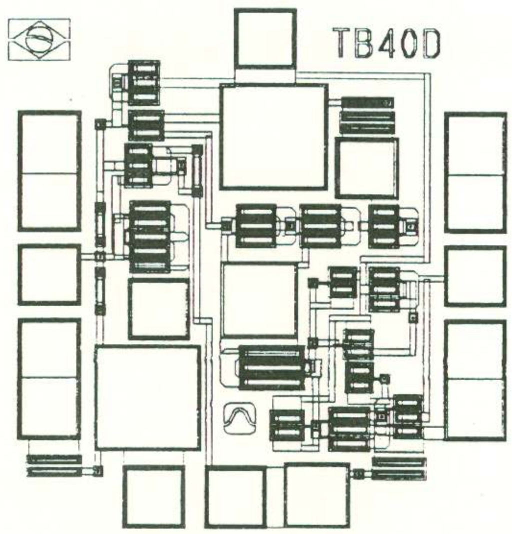

Figure 3 - Lay-out TB 40D

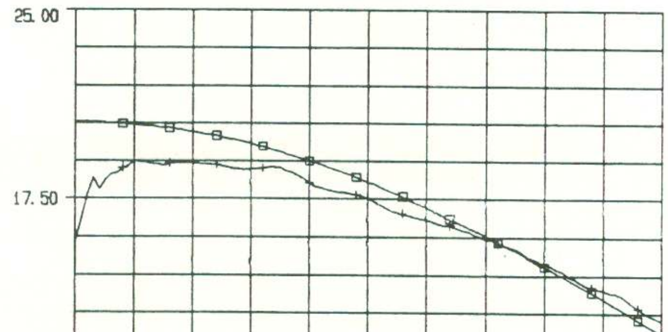

Figure 4 - Gain x Frequency

This capacitance also contributes to improve the input impedance, affecting the transimpedance bandwidth.

In fig. 6 the transimpedance gain is plotted. The result obtained is 1.9 GHz bandwidth with gain aproximately 61 dBohm. This gain reduction was caused by weak active load (T5) (current source) in the second stage - differential amplifier. This problem affected the total gain (S_{21}) causing a reduction of about 5 dB in the expected gain.

In the fig. 7 the S_{22} parameter is shown. The ouptut impedance is nearly 50 ohms.

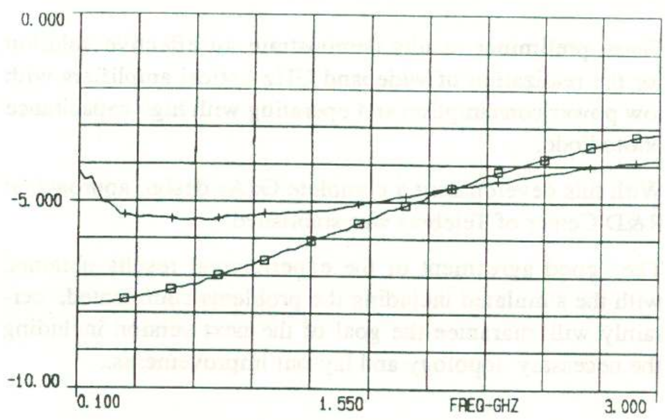

Figure 5 - Input Return Loss x Frequency

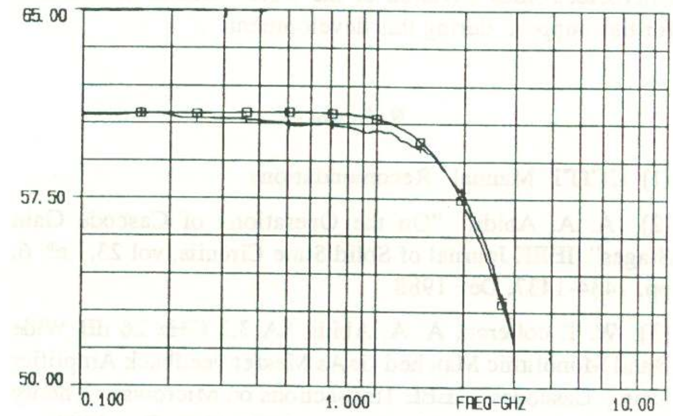

Figure 6 - Transimpedance Gain x Frequency

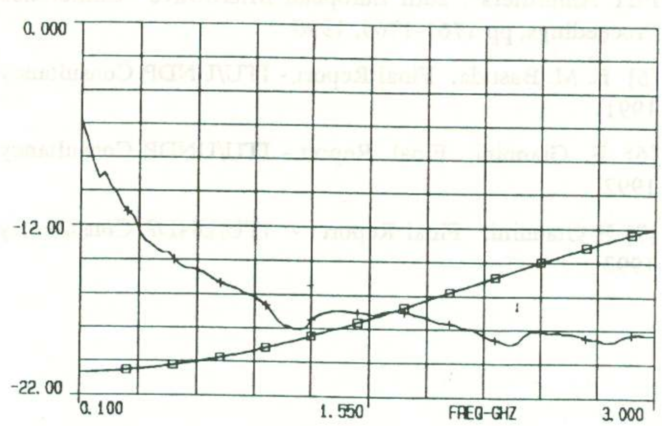

Figure 7 - Output Return Loss x Frequency

A typical power consumption of about 440 mW has been measured.

In all the figures the curves with + indicate experimental results and the curves with □ indicate simulated results including the problems detected.

Conclusion

These preliminar results demonstrate an effective solution for the realization of wideband GHz optical amplifiers with low power consumption and operating with high capacitance photodiode,

With this development a complete GaAs design approach at R&D Center of Telebrás was stablished.

The good agreement of the experimental results obtained with the simulated including the problems commented, certainly will guarantee the goal of the next version including the necessary topology and lay-out improvements..

Acknoledgements

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