0.6μm CMOS Laser Diode Driver for Optical Access Networks*

Liang Bangli\(^1\), Wang Zhigong\(^1\), Tian Jun\(^1,2\), Xia Chunxiao\(^1\), Zhang Li\(^1\) and Xiong Mingzhen\(^1\)

(1 Institute of RF&E-ICs, Southeast University, Nanjing 210096, China)
(2 Department of Physics, Nanjing University, Nanjing 210093, China)

Abstract: Using native CMOS technology, EDA tool, and adopting full-custom design methodology, a laser diode driver for the use of STM-1 and STM-4 optical access network, is realized by CSMG-HJ 0.6μm CMOS technology to modulate laser diodes at 155Mb/s (STM-1), 622Mb/s (STM-4) with adjustable modulation current from 0 to 50mA for an equivalent 50Ω load. The maximum modulation voltage is over 2.5Vpp corresponding to a 3V DC bias for output stage. The time range of rise and fall from 360ps to 471ps is measured from the output voltage pulse. The RMS jitter is no more than 30ps for four bit rates. The power consumption is less than 410mW under a power supply voltage of 5V. According to the experimental results, the laser diode driver achieves the same level as their counterparts worldwide.

Key words: laser diode driver; CMOS; optical access networks

EEACC: 1230B: 7250E


1 Introduction

With the rapid development of optical networks, super performance and low cost of optical transmitters are needed\(^1,2\). The best choice to realize such optical transmitters is through CMOS technology. CMOS technologies are playing an increasingly important role in super performance ICs for the use of optical fiber communications due to the low cost and the great progress of CMOS technology itself\(^3,4\). In the past years, other laser diode driver was realized through InP-based technology\(^5\) within China mainland. However, for the low cost commercial application of optical access network operating at low data speed, in this work, a laser diode driver was realized by CSMG-HJ 0.6μm CMOS technology, which can meet the requirement of 155Mb/s and 622Mb/s optical transmitters.

2 Circuit design and simulation

The schematic diagram of the circuit is shown in Fig. 1. The DC-coupled, fully differential circuit consists of an input buffer, two amplifying stages and an output stage. The whole circuit is fully balanced by employing differential amplifiers to maximize its work speed.

The upper NMOS transistor pair in each amplifying stage is a differential current amplifier. The lower transistor forms the current source for the NMOS transistor pair.

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Liang Bangli  male, engineer. Now he majors in IC design and design kits development.

Wang Zhigong  male, professor. Now he is involved in RF&E-ICs design.

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3 Circuit fabrication

The laser diode driver was designed using 0.6μm double-poly double-metal N-well CMOS technology and fabricated in Wuxi CSMG-HJ Semiconductor Co., Ltd. The chip microphotograph of the die is shown in Fig. 2. The chip dimensions including bonding pads are 0.7mm × 1.0mm. On the chip, only one tenth of the total chip area in the middle region was used for the active part.

![Microphotograph of the fabricated CMOS laser diode driver](image)

A very important fact should be pointed out that the chips for the use of optical transmitters in optical access networks were realized within China mainland all by native resources such as PANDA system, a layout EDA software of CIDC (China Integrated Circuit Design Center), IC manufacturing line of Wuxi CSMG-HJ Semiconductor Co., Ltd. All design kits were developed by IROI (Institute of RF & OE ICs.), Southeast University and the support from the MPW plan of Shanghai ICC.

4 Experimental results

The performance of the fabricated laser diode driver was evaluated via on-wafer probing on uncut wafers employing CASCADE MICROTECH probe station, an ADVANCE D3186 Pulse Pattern Generator, an ADVANCE R6142 Programmable DC Voltage/Current Generator, a ROHDE & SCHWARZ SMP04 Signal Generator (10MHz~ 40GHz) and an Agilent Infinium DCA 86100A Wide-bandwidth Oscilloscope. The DC current of the laser diode driver under a supply voltage of 5V was less than 82mA, corresponding to a power dissipation of 410mW.
The circuit was tested using an input PECL of 500mVpp at different bit rates. The measured eye diagrams at the bit rates of 155, 622, 1250, and 1600Mbps from one single-ended output of the laser driver are shown in Figs. 3 (a), (b), (c), and (d). The modulation current range at each single-end output is 0~ 50mA.

Fig. 3 (a) Output eye diagram at 155Mbps; (b) Output eye diagram at 622Mbps; (c) Output eye diagram at 1250Mbps; (d) Output eye diagram at 1600Mbps

Testing data without external DC bias on output stage are filled in Table 1. The maximum modulation voltage is over 2.36Vpp corresponding with a 1.93V internal DC bias for output stage. The maximum rise time and fall time are 471ps and 360ps, respectively. And the RMS jitter is below 30ps for four bit rates. The power consumption is below 410mW under the single supply voltage of 5V.

Moreover, this driver circuit can work well with different modulation current swings under the single supply voltage ranging from 4V to 6V.

By the comparison between the simulated values and the measured values of several major parameters shown in Table 2, we can come to a conclusion that the performance of the fabricated chip verges on the anticipant result and can operate well at bit rates of 155, 622, and 1250Mbps.

Table 1 Testing data without external DC bias on output stage

<table>
<thead>
<tr>
<th>Data rate f (Mbps)</th>
<th>Input signal swing/mV</th>
<th>Modulate voltage/V</th>
<th>Output signal swing/V</th>
<th>Supply current I/mA</th>
<th>RMS jitter t/ms</th>
<th>Rise t/rise ms</th>
<th>Fall t/fall ms</th>
</tr>
</thead>
<tbody>
<tr>
<td>155</td>
<td>500</td>
<td>1.93</td>
<td>2.36</td>
<td>80.30</td>
<td>30</td>
<td>400</td>
<td>360</td>
</tr>
<tr>
<td>622</td>
<td>500</td>
<td>1.93</td>
<td>2.34</td>
<td>80.40</td>
<td>13</td>
<td>444</td>
<td>367</td>
</tr>
<tr>
<td>1250</td>
<td>500</td>
<td>1.93</td>
<td>2.33</td>
<td>81.50</td>
<td>15</td>
<td>440</td>
<td>400</td>
</tr>
<tr>
<td>1600</td>
<td>500</td>
<td>1.93</td>
<td>2.18</td>
<td>81.75</td>
<td>14</td>
<td>471</td>
<td>444</td>
</tr>
</tbody>
</table>

Table 2 Comparison between simulated values and measured values

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Simulated value @ VDD = 5V</th>
<th>Measured value @ VDD = 5V</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOS.txt-_monitor</td>
<td>2.98V</td>
<td>3.0V</td>
</tr>
<tr>
<td>VCE</td>
<td>1.214V</td>
<td>1.17V</td>
</tr>
<tr>
<td>VCE</td>
<td>1.997V</td>
<td>1.93V</td>
</tr>
<tr>
<td>VOIIP</td>
<td>2.62V</td>
<td>2.18~ 2.36V</td>
</tr>
<tr>
<td>Supply current IRD</td>
<td>80mA</td>
<td>80~ 81.75mA</td>
</tr>
</tbody>
</table>

5 Conclusion

A laser diode driver for the use of optical transmitters in passive optical networks has been realized using CSMC-HJ 0.64µm CMOS technology. The laser driver provides a modulation current range of 0~ 50mA for an equivalent 50Ω load. It can operate at bit rates of 155, 622, 1250, and 1600Mbps with the rise time and fall time
of the voltage pulse falling inside the scale from 360ps to 471ps and lower RMS jitters than 30ps. The power consumption is below 410mW under a supply voltage of 5V.

To sum up, this laser diode driver realized by CSMG-HJ 0.6μm CMOS technology can meet the requirement of 155Mb/s and 622Mb/s optical transmitters.

References


可用于光纤用户网的 0.6μm CMOS 激光驱动器

梁帮立1 王志功1 田 俊1,2 夏春晓1 章 明1 熊明珍1

（1 东南大学光纤与光通信集成电路研究所，南京 210096）
（2 南京大学物理系，南京 210093）

摘要：基于国内的 CMOS 技术和 EDA 工具以及全定制的设计方法，采用无锡华晶半导体（CSMG-HJ）0.6μm CMOS 技术实现了可工作于 155Mb/s 622Mb/s 的激光驱动器。该激光驱动器在 50Ω 负载上输出电流摆幅从 0 到 50mA 可调，在输出级 3V 直流偏置时最大输出电压摆幅可达 2.5V。输出电压脉冲的上升下降时间分别小于 471ps 和 444ps，四个工作速率下均方根抖动都小于 30ps。电路在 5V 单电源供电时功耗小于 410mW。芯片测试结果表明，该激光驱动器达到了世界同类集成电路的水平。

关键词：激光驱动器；CMOS；光纤用户网

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梁帮立，男，工程师，研究方向为集成电路设计与设计套件开发。

王志功，男，教授，研究方向为射频与光通信集成电路设计。

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