A Comparative Study of the Effect of Analogue Pre-equalisers on VLC System Data Rates

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Introduction

- The goal of this research is to investigate the fundamental principle behind the analogue pre-equaliser.
- Based on the principle, multi-carrier modulation with bit loading can outperform the VLC system with analog equalisers.

Pre-equaliser design method

![Diagram of LED driver and pre-equaliser](image)

**Figure 1:** Driver and pre-equaliser for the LED.

Analogue pre-equaliser design examples

<table>
<thead>
<tr>
<th>Type</th>
<th>Value</th>
<th>DC SNR loss</th>
<th>System bandwidth with EQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>designed</td>
<td>measured</td>
<td>designed</td>
</tr>
<tr>
<td>EQ1</td>
<td>111 Ω/200 pF</td>
<td>6.5 dB</td>
<td>15 MHz</td>
</tr>
<tr>
<td>EQ2</td>
<td>240 Ω/82 pF</td>
<td>10.6 dB</td>
<td>27 MHz</td>
</tr>
<tr>
<td>EQ3</td>
<td>510 Ω/42 pF</td>
<td>15.7 dB</td>
<td>45 MHz</td>
</tr>
</tbody>
</table>

*The DC SNR loss is calculated by $20 \log \left( \frac{R_0}{R_0 + R_{eq}} \right)$.*

Data rate comparison between equaliser and bit loading

![Frequency response of the red LED (raw bandwidth 7.5 MHz) with EQs](image)

**Figure 5:** Frequency response of the red LED (raw bandwidth 7.5 MHz) with EQs

SNR or BW: easier to understand in the frequency domain!

![Measured spectrum of the received signal for 5-CAP with no EQ, EQ1 and EQ2 (1 GHz receiver Newport 1601 used)](image)

**Figure 7:** Measured spectrum of the received signal for 5-CAP with no EQ, EQ1 and EQ2 (1 GHz receiver Newport 1601 used)

Conclusion

- The pre-equaliser based system can increase the data rate by extending the normalised 3-dB bandwidth at the cost of SNR penalties;
- However, VLC with multi-carrier modulation and bit-loading offered higher data rates because of no SNR penalties and higher spectrum efficiency;
- We experimentally demonstrated that for VLC with equalisers the data rate increased from 61 to 174 Mb/s when the equalised bandwidth was extended from 7.5 MHz to 48 MHz. In comparison to equalised VLC systems, the raw LED based VLC system achieved a data rate of 246 Mb/s by using 20-CAP with bit loading.

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