Sudan University of Science and Technology
College of Graduate Studies

Laser chaos generation, modulation and synchronization by electro-optical feedback in communication systems

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الضوئية - الكهربائية في نظام الاتصالات

A thesis
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الهداء

الى:

جذوري ........... العراق
الجبال الشامخة...... ابي و اخواني رحمهم الله
نهر العطاء.............امي اطال الله عمرها
النخلات الباسقات...... اخواتي وفقهن الله
زوجي العزيز........... قيس
زهرات حياتي........... بناتي زينب دانية رحمة

اهديهم جهدي المتواضع هذا
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Abstract

Chaotic dynamics are at the center of multiple studies to perfect encrypted communication systems. Indeed, the particular time evolution nature of chaotic signals constitutes the fundamentals of their application to secure the optical communications. The information coded on the carrier wave can be extracted with knowledge of the system dynamic evolution law.

The work presents the implementation of experimental chaos generation systems by means of electro-optic feedback of the semiconductor laser. The output photocurrent of the optical receiver is amplified and reinjected as a feedback to the semiconductor laser source. The injected feedback photocurrent produces a chaotic behavior in the laser output.

The change of the chaotic series and its jump from chaotic to periodic form depends on the initial operation condition of the laser diode and on the amplification of the injected feedback photocurrent. The chaotic signal has been used as a carrier for data transmission, the phase masking technique was used during the work. The data (message) signal was injected with the chaotic signal.

Finally, two of the chaotic laser systems have been established to find the synchronization between two chaotic attractors. This step was done in order to extract the encoded message via the chaotic laser system.
المستخلص

تعد ديناميكيا الشواش أو الفوضى الحاكمة في الليزرتا مركزا لدراسات متعددة تهدف إلى تحقيق أمان نام للاتصالات الصوتية. في الحقيقة، تُشكّل طبيعيّة تطور الإشارات الفوضوية أساس لتطبيقات ضمان أمان الاتصالات بواسطة التشغيل. يمكن استخلاص المعلومات المشفرة على الموجه الحاملة بمعرفة قانون تطور النظام الديناميك ي.

في هذا البحث جرى تطبيق أنظمة توليد الفوضى تجريبيا بواسطة التعليقات الكهرو البصرية في ليزر شبه الموصل.

يضع التيار الكهروضوئي للمستقبل البصري وحقن ثانية كتغذية عكسية للمصدر الليزري شبه الموصل. ينتج التيار الكهروضوئي المعزز عكسيا سلوك فوضوي في خرج الليزر.

تغيب سلوك الفوضى أو الشواش وقفرته محل فوضوي من فوضي إلى شكل دوري يعتمد على حالة التشغيل الابتدائية للليزر و على مقدار التكبير في تيار الحقن الكهروضوئي.

تم خلال العمل استعمال إشارة الشواش أو الفوضى كإشارة حاملة لنقل المعلومات باسلاوب فتاع الطور تم تحميل البيانات (رسالة) على الإشارة الفوضوية.

أخيرا تم بناء نظامين فوضويين لإجراء عملية التزامن بينهما كأساس لنظام اتصالات متكامل. تم عمل هذه الخطوة لاستخلاص البيانات المرسلة خلال نظام شوشا (الفوضى) الليزري.

تم اختيار النظام بمعلومات مختلفة وأثبتت نجاحه كنظام عالي الامان للاتصالات الصوتية.
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<th>TDS</th>
<th>Theory of Dynamical Systems</th>
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<tr>
<td>DF</td>
<td>Maximum Frequency Deviation</td>
</tr>
<tr>
<td>EM</td>
<td>Electromagnetic</td>
</tr>
<tr>
<td>GaAs</td>
<td>Gallium Arsenide</td>
</tr>
<tr>
<td>GaAlAs</td>
<td>Gallium Aluminum Arsenide</td>
</tr>
<tr>
<td>InP-InGaAsP</td>
<td>Indium Phosphate Gallium Aluminum Arsenide Phosphate</td>
</tr>
<tr>
<td>LED</td>
<td>Light Emitting Diode</td>
</tr>
<tr>
<td>APD</td>
<td>Avalanche Photodiode</td>
</tr>
<tr>
<td>OCS</td>
<td>Optical Chaos Synchronization</td>
</tr>
<tr>
<td>CS</td>
<td>Chaos Synchronization</td>
</tr>
<tr>
<td>EDFRL</td>
<td>Erbium-Doped Fiber Ring Laser</td>
</tr>
<tr>
<td>SL</td>
<td>Synchronization Link</td>
</tr>
<tr>
<td>SSU</td>
<td>Synchronization Supply Unit</td>
</tr>
<tr>
<td>PRC</td>
<td>Primary Reference Clock</td>
</tr>
<tr>
<td>MB</td>
<td>Maxwell- Bloch</td>
</tr>
<tr>
<td>DFB</td>
<td>Distributed Feedback</td>
</tr>
<tr>
<td>CW</td>
<td>Continuous Wave</td>
</tr>
<tr>
<td>MCL</td>
<td>Multi-Channel Lasers</td>
</tr>
<tr>
<td>NEP</td>
<td>Noise Equivalent Power</td>
</tr>
<tr>
<td>CMRR</td>
<td>Common Mode Rejection Ratio</td>
</tr>
<tr>
<td>PVG</td>
<td>Precision Voltage Generator</td>
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