Application

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2015-04892 **Magesacher, Thomas** **NT-14**

Information about applicant

Name: Thomas Magesacher
Doctorial degree: 2006-09-28
Birthdate: 19740507
Academic title: Docent
Gender: Male
Employer: Lunds universitet
Administrating organisation: Lunds universitet
Project site: Elektro- och informationsteknik 107201

Information about application

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Participants

Name: Per Ola Börjesson
Doctorial degree: 1980-05-27
Birthdate: 19450908
Academic title: Professor
Gender: Male
Employer: Lunds universitet

Descriptive data

Project info

Project title (Swedish)*

Modellering av plötsliga trådbundna kanaländringar

Project title (English)*

Modeling of abrupt wireline channel changes

Abstract (English)*

This project deals with modeling abrupt changes of wireline matrix channels. The driving application are next-generation small-cell mobile networks - a concept that hinges upon backhaul connections offering high throughput and high reliability. The wireline access network, originally installed for voice telephony, is a nearly ideal candidate for providing the backhaul link between cells located in bandwidth-hungry locations such as customers´ homes or office buildings and the core network. Sudden channel changes can be caused by sudden changes of termination impedances on neighboring lines due to changes of their operation modes or unwanted disconnect events. The underlying premise of the project is that sudden changes in a matrix channel are caused by singular events and are thus of sparse nature. The goal is to augment multi-conductor transmission-line theory by sudden termination changes and to create counter measures such as fast and low-complexity estimators.

Popular scientific description (Swedish)*

En matriskanal är en matematisk modell av ett system med flera ingående och flera utgående signaler. Exempelvis transmissionen mellan en modern mobiltelefon och en basstation är en matriskanal. En telefonkabel som förbinder hemmen med telefoncentralen är ett annat exempel. Grundidén i projektet är att det oftast finns en enskild orsak som leder till plötsliga ändringarna i matrisen. Eftersom den plötsliga ändringen oftast kan beskrivas på ett enkelt sätt (vilket betyder att den matematiska modellen bara har ett fåtal koefficienter), borde också ändringarna i matrisen vara mindre komplicerade än det verkar. Projektets mål är att utveckla effektiva metoder för snabb uppdatering av matriskanaler som beter sig enligt beskrivningen ovan, samt skapa grundläggande kunskap inom området.

Project period

Number of project years*

2

Calculated project time*

2016-01-01 - 2017-12-31

Classifications

Select a minimum of one and a maximum of three SCB-codes in order of priority.

Select the SCB-code in three levels and then click the lower plus-button to save your selection.

SCB-codes*	2. Teknik > 202. Elektroteknik och elektronik > 20204. Telekommunikation

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Enter a minimum of three, and up to five, short keywords that describe your project.

Keyword 1*

wireline

Keyword 2*

modeling

Keyword 3*

estimation

Keyword 4

vectoring

Keyword 5

wideband

Ethical considerations

Specify any ethical issues that the project (or equivalent) raises, and describe how they will be addressed in your research. Also indicate the specific considerations that might be relevant to your application.

Reporting of ethical considerations*

To the best of the applicants' knowledge, there are no ethnical concerns raised by this project.

The project includes handling of personal data

No

The project includes animal experiments

No

Account of experiments on humans

No

Research plan

Contents

A.1 Purpose and aims

The classic wireline channel is modeled as quasi-time-invariant dispersive matrix channel exhibiting only very slow temporal variations caused by changes of environmental variables such as temperature or humidity. However, emerging throughput-boosting techniques such as extending the used bandwidth and exploiting alternative transmission modes introduce new challenges not covered by the traditional modeling approach. A performance-devastating issue discovered only recently are abrupt changes of the entire matrix channel caused by termination-impedance variations.

Successful application of capacity-exploiting techniques requires a paradigm shift away from time invariance to models and methods capable of capturing sudden changes. The approach of this proposal is the following: instead of applying state-of-the-art estimation techniques to identify a "black-box" matrix change on system level, we instead analyze the underlying mechanisms and aim at exploiting structural properties of an abrupt impedance-induced channel change. A key observation is that most often only a single user causes a termination change at a given time instant. The project's main conjecture is that sudden wireline matrix-channel changes are rooted in singular scalar impedance changes and should thus be of sparse nature. The project's goal is to advance the state of the art in the following way:

- Proof the sparsity conjecture
- Augment the time-invariant multi-conductor transmission-line model by the ability to capture a sudden transition between two stationary states
- Create techniques to mitigate the impact of sudden transitions based on the model and exploiting the sparsity property

A.2 Survey of the field

Broadband Internet access via the in-place copper network is an important part of today's fixed broadband-access infrastructure [1] and emerging broadband access systems [2]. In future, the existing copper infrastructure is likely to play a key role in small-cell networks [3]. System architecture proposals range from backhauling of data over digital subscriber line links to amplify-and-forward fronthauling of analog signals over copper lines connecting low-power radio nodes with multi-cell access points [4, 5].

A cable or a cascade of several cables can be modeled in frequency domain by a matrix $H(f) \in \mathbb{C}^{m \times m}$, where f denotes frequency and m denotes the number of transmission modes. Using differential modes[1], a cable with m pairs provides m modes. The receive signal $y(f) \in \mathbb{C}^m$ is given by

$$y(f) = H(f)x(f) + z(f), \tag{1}$$

where $x(f) \in \mathbb{C}^m$ and $z(f) \in \mathbb{C}^m$ denote transmit signal and noise, respectively. In order to simplify notation, the dependence on f is hereinafter omitted wherever possible.

Co-location of transceivers allows for coordination with the aim of better exploiting the channel by techniques summarized under the term dynamic spectrum management (DSM) [6]. In its most advanced form, DSM employs joint signal processing and corresponding pre-coding/ interference-cancellation techniques are often summarized under the term vectoring or vectored transmission [7–11]. Transceivers participating in joint processing form a so-called vectoring group. Co-location of transmitters allows for joint pre-processing of signals before transmission, which is frequently referred to as pre-coding and can be described by a (possibly non-linear) operator $\mathcal{P}(\cdot)$ turning (1) into $y' = Hx' + z = H\mathcal{P}(x) + z$. Co-location of receivers allows for joint post-processing of receive signals by a (possibly non-linear) operator $\mathcal{C}(\cdot)$, which is frequently referred to as interference cancellation and can be described by $y' = \mathcal{C}(y) = \mathcal{C}(Hx + z)$. In essence, vectoring aims at turning (1) into an equivalent system

$$y' = (D + R)x' + z', \tag{2}$$

where D is diagonal, R contains residual coupling values, and z' is a possibly modified noise vector. Ideally, the diagonal of D is large and balanced according to the desired throughput distribution over the modes and R vanishes.

Vectoring techniques applied to shielded or unshielded twisted-pair cables rely on accurate channel information since they aim at eliminating interference that lies up to 70 dB below signal level resulting in spectral efficiencies of up to 12 bit/s/Hz/dimension. In order to exploit the capacity of the matrix wireline channel, vectoring techniques require channel estimates with relative errors in the order of 0.1–1%. For state-of-the-art wireline systems, which use relatively low bandwidths (up to 30 MHz) and differential modes, the time-invariance assumption for H is valid, which allows for accurate channel estimation.

Emerging and future wireline systems aim at fulfilling the ever-increasing throughput demand mostly by following two main trends:

- Exploit higher frequencies on short lines [2, 12]
- Employ alternative transmission modes (such as phantom modes, common modes, or split-pair modes) [13–16] instead of or in combination with traditional differential modes

For frequencies beyond roughly 30 MHz, $H(f)$ becomes increasingly sensitive to termination impedances. This issue was discovered only recently [17–21] and shatters the time-invariance

[1]Differential modes are created by applying a voltage between two conductors which are typically twisted in order to improve the mode's electromagnetic immunity.

assumption since termination impedances change abruptly when users disconnect or turn on/off equipment and are thus unpredictable events. Vectoring systems often share the channel infrastructure with other systems (which may be separated through frequency division but nevertheless interfere on termination-impedance level) owned by a different operator, which makes it difficult to circumvent the problem on equipment level (for example, by installing fixed terminations). An abrupt channel change can be modeled by a new matrix

$$H'(f) = H(f) + \Delta(f), \tag{3}$$

where $\Delta(f)$ is a full $m \times m$ matrix. The vectoring system, which is tuned to $H(f)$, suddenly operates on $H'(f)$. As a result, the diagonal of D in (2) changes, a possibly substantial residual R appears, and z' may grow. The system is seriously impaired, which causes transmission errors or even loss of synchronization. Estimating $H'(f)$ to get back on track is vital. State-of-the-art estimation techniques face two major challenges:

- Estimation complexity is enormous[2] since tackling the change $\Delta(f)$ requires $m^2 n_\mathrm{f}$ parameters, where n_f denotes frequency resolution.
- Estimating $H'(f)$, or equivalently $\Delta(f)$, has to happen fast. Although error bursts up to a certain length can be mitigated by higher-layer channel-coding techniques, latency and coding complexity impose limits and thus require the vectoring system to quickly move from $H(f)$ to $H'(f)$.

Prior work focused on the related sub-problem of channel changes caused by termination variations on lines that are part of the vectoring group, which is simpler for two reasons: first, only one column of H experiences significant changes, which reduces the number of parameters per frequency point to m and makes black-box tracking easier[3] [22, 23]; second, the termination-changing line is either leaving or joining the group, which anyway requires an update of the matrix-channel estimate and allows for system-level techniques such as muting the leaving transmitter [24]. None of these approaches, however, can be used for full matrix channel changes induced by termination changes of lines outside the vectoring group. Underlying theory and corresponding methods of this proposal are outlined in the next section.

A.3 Project description

A.3.1 Underlying theory and approach

The core conjecture of the project is that wireline matrix-channel changes are caused by singular scalar impedance changes: most often, only a single user causes a termination change. Consequently, although $\Delta(f)$ in (3) is a full matrix, the change should be of sparse nature. The sparsity conjecture is motivated by prior work [25] on a simplified coupling-and-reflection-mechanism

[2]For example, a 10-pair cable ($n = 20$) driven solely with differential modes ($m = 10$) requires already $m^2 = 100$ complex-valued parameters per frequency point. Exploiting all $m = n - 1$ independent transmission modes in a 20-pair cable ($n = 40$) yields $m^2 = 1521$ parameters per frequency point. The recently introduced standard G.fast uses $n_\mathrm{f} = 4096$.

[3]Black-box tracking still requires high complexity and can be improved by applying the approach outlined in this proposal also to the case of termination-variations inside the vectoring group.

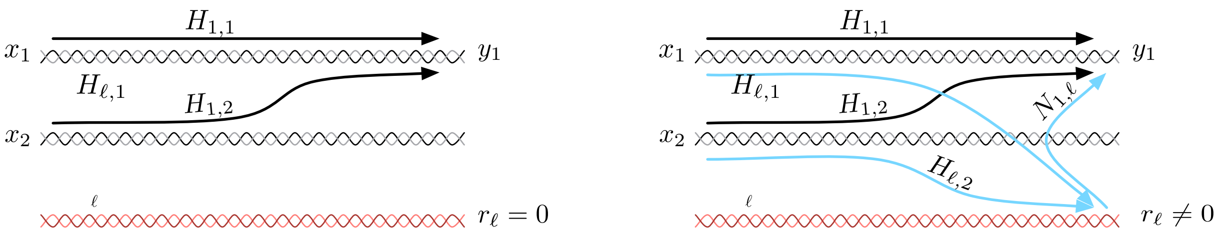

Figure 1: Illustration of the model's idea for downstream coupling from line no. 2 to line no. 1. Line no. ℓ is the line changing its termination. Left: In case of perfect termination ($r_\ell \approx 0$), the received signal is simply $y_1 = H_{1,1}x_1 + H_{1,2}x_2$. Right: In case of a termination mismatch ($r_\ell \neq 0$), the components $H_{\ell,1}x_1 + H_{\ell,2}x_2$ arriving at the mismatched port are reflected and yield an additional far-end crosstalk component $N_{1,\ell}r_\ell H_{\ell,1}x_1 + N_{1,\ell}r_\ell H_{\ell,2}x_2$ through the near-end crosstalk coupling path.

briefly outlined in the following. Consider two differential modes of a small vectored group in an n-conductor cable. In case all termination impedances match perfectly (cf. Fig. 1 left), the receive signal on line 1 can be written as

$$y_1 = H_{1,1}x_1 + H_{1,2}x_2. \tag{4}$$

Now assume that the termination of line no. ℓ is changing, which causes a mismatch and thus a reflection of arriving signal energy (cf. Fig. 1 right). Let r_ℓ denote the ratio of reflected and arriving signal. The receive signal can then be written as

$$y_1 = \underbrace{(H_{1,1} + N_{1,\ell}r_\ell H_{\ell,1})}_{H'_{1,1}} x_1 + \underbrace{(H_{1,2} + N_{1,\ell}r_\ell H_{\ell,2})}_{H'_{1,2}} x_2, \tag{5}$$

where the element $N_{i,j}$ of the matrix N denotes the coupling coefficient from line j to line i at the receive side. Extending (5) to all m modes in the vectored group yields

$$y = \underbrace{(H_{1:m,1:m} + N_{1:m,\ell}\, r_\ell\, H_{\ell,1:m})}_{H'_{1:m,1:m}} x \tag{6}$$

The change $\Delta = N_{1:m,\ell}\, r_\ell\, H_{\ell,1:m}$ of all entries in H is caused by the change of the scalar reflection coefficient r_ℓ.

Although the coupling-reflection approach (6) inspired by [25] is a good starting point to recognize sparsity, several issues arise when using it as a basis for the extension to the general case of m modes and several lines with changing impedances. First, as soon as two or more lines are mismatched, the model suggests multiple reflections (back and forth between mismatched ports), which complicate the analysis. Second, the assumption that a line is perfectly terminated in its characteristic impedance never holds in practice. Consequently, the coupling coefficients available in real systems describe the termination state under which they have been identified and are thus *not necessarily equivalent* to scattering parameters[4]. Third, coupling coefficients

[4]In fact, crosstalk coefficients might deviate significantly from scattering parameters in case channel estimation or tracking is performed while a line is open or short-circuited.

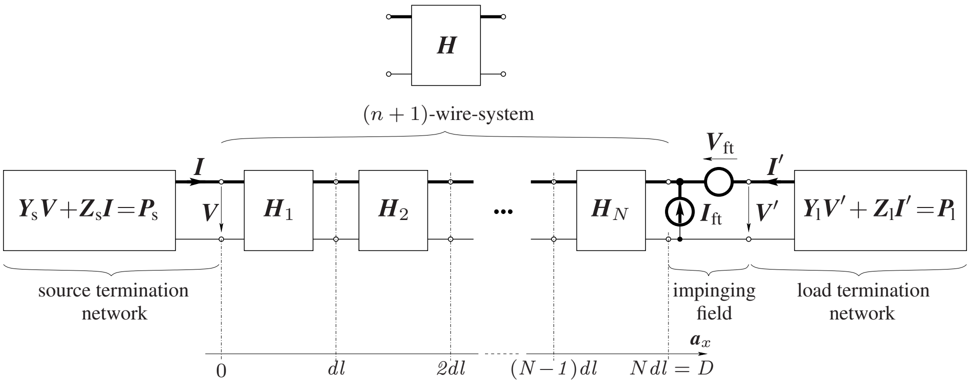

Figure 2: Chain-parameter model of multi-segment multi-conductor transmission line system including general matrix termination networks (mixed representation of generalized Thevenin equivalent and generalized Norton equivalent [26]).

to and from ports of a line outside the vectoring group are in general not available to the vectoring system. The project will approach the problem in a more rigorous way starting with a complete chain-parameter description based on multi-conductor transmission-line (MTL) theory [26] (cf. Fig. 2). MTL modeling includes matrix terminations of the multi-conductor system instead of considering only individual and decoupled mode-terminations. Furthermore, it allows circuit-level modeling of termination networks. Subsequent symbolic conversion to scattering parameters by extending the corresponding results of [27] to six ports (three lines, two out of which form a small vectoring group while the third changes its termination) allows for a formal proof of sparsity. Although the number of MTL-model parameters is larger compared to a coupling model like (6), it enables a systematic approach to establishing sparsity by answering the following fundamental questions:

- How sensitive are crosstalk coupling coefficients to inter-mode termination impedances[5]?
- How much information in terms of scattering parameters and their accuracy is required in order to predict crosstalk coupling changes caused by scalar termination-impedance changes?

A.3.2 Work packages and timeline

The two-year project is organized in work packages (WPs) and the timeline is specified in terms of 24 project months (PMs).

WP1: Model design (PM 1-14) The first step is building the scattering-parameter model of a cable with arbitrary geometry and general terminations using chain-parameter based multi-conductor transmission-line theory [26, 28]. A sensitivity analysis shall yield bounds for the crosstalk-coupling changes caused by inter-mode terminations. While inter-mode terminations are essentially neglected in low-frequency differential-mode wireline systems, their impact for

[5]For differential modes, inter-mode termination impedances originate for example from stray capacitors between conductor ends belonging to different twisted pairs.

frequencies beyond 100 MHz and, in particular, for alternative transmission modes has to be investigated.

A case of particular practical relevance is variation of modes' insertion losses. In real scenarios, the impedance-changing line can have a different length than the other lines affected by the change. The model will provide a methodology to answer questions regarding the impact of line-length differences between impedance-changing and affected lines.

Frequency-domain modeling of termination impedance and the corresponding reflection coefficient offers another degree of sparsity. Instead of modeling the termination as black box with n_{f} frequency-domain coefficients, which requires several hundred parameters[6], a circuit model of the termination network requires only a few parameters.

WP2: Model verification through laboratory measurements (PM 12-16) In order to manifest the model's credibility, laboratory measurements of representative test scenarios are carried out to assess the match between measured and predicted channel after a termination-impedance change. Interesting cases from an application point of view are transitions from matched (or close to matched) termination to open state (cable break event or equipment disconnect) and short-cut state (cable damage). Several combinations of differential modes, phantom modes, and split-pair modes on various cable types (category 3, 5, and 7) shall be verified.

WP3: Model-based transceiver design (PM 17-24) This work package aims at improving the state-of-the-art wireline transceiver by exploiting the insights of WP1 and WP2. The main strain of work shall focus on reducing the complexity of linear matrix-channel estimation by invoking the scattering model and exploiting sparsity. Circuit-based modeling of the termination has the potential of reducing the number of parameters by several orders of magnitude—however, good models will most likely result in nonlinear estimators, which thus requires a careful complexity analysis.

The second strain of work focuses on system-level aspects of abrupt channel changes. The goal is to mitigate the impact of the channel change by exploiting insights gained from modeling. For example, keeping the vectoring engine running after a termination-change has been detected, can minimize the signal energy arriving at the mismatched port and thus reduce the change's duration-of-impact to the time required to detect the change [29]. The project shall extend the idea to non-linear precoding techniques, which are applied at higher frequencies, as well as to the case when a change is reversed (for example, by a dropped line coming back online).

A.3.3 Project organization and research group

The project will be carried out in cooperation with Ericsson Research AB in Kista, Stockholm, where most of the participating research team is placed:

[6] Although state-of-the-art systems divide the available bandwidth into several thousand subcarriers, they eventually form several hundred groups of adjacent subcarriers sharing the same channel information in order to lower the number of parameters.

- Yezi Huang (PhD student at Lund University, based at Ericsson Research in Stockholm). Supported by and working full-time on the project.
- Eduardo Medeiros (PhD student at Lund University and research engineer at Ericsson Research based in Stockholm). Working part-time on the project with most involvement in WP2.
- Per Ola Börjesson (PhD, Docent, Professor at Lund University). Co-applicant and co-supervisor of PhD students.
- Thomas Magesacher (Docent, Associate Professor at Lund University, based at Ericsson Research in Stockholm). Main applicant, project leader, PhD student supervisor.

Cooperation with Ericsson Research enables access to test cables, laboratory equipment, and vector signal analyzers required for the verification step. The research group has a background in the area of wireline channel modeling working in this hybrid academia/industry constellation on several projects, for example, "High-frequency reflection and transmission channels" (VR-2008-3883) and "Joint space-frequency modelling of twisted-pairs for Gigabit transmission" (VR-2011-5831).

A.4 Significance

The issue of sudden termination-induced channel changes is of great interest to communication system designers and equipment providers and has been recognized by standardization bodies and industry consortia such as ITU and Broadband Forum [17–20]. From a scientific point of view, our preliminary work [21] on assessing the impact of sudden channel changes has already received substantial recognition by our academic peers through two best-paper awards at the community's flagship conference.

Last but not least, the project is motivated by a concrete application: enabling next-generation wireline access system as well as backhaul transmission over the access network for emerging small-cell networks. The group's close cooperation with the world's leading mobile-network infrastructure designer as industry partner can enable the exploitation of successful concepts developed by this project within a few years.

A.5 Preliminary results

Unless stated otherwise, citations in this section refer to our own work. As bandwidth grows, termination mismatch has more and more impact on the performance of wideband vectoring systems. In practice, a termination mismatch on the customer-premises side occurs when users turn off or disconnect their equipment or simply pick up their phones. At the network-side, a termination mismatch may—although probably less frequently—be caused by imperfect maintenance. Measurements have shown that termination mismatch causes enormous matrix-channel changes [30]. The results have been confirmed by other groups [17–19].

First evaluations of the corresponding impact on performance are dramatic [21]. Fig. 3 illustrates the signal-to-noise power ratio (SNR) degradation for a user employing vectoring before and after changing the termination of a single line outside the vectored group. Lines or users outside the vectored group do neither participate in joint processing of signals nor can they

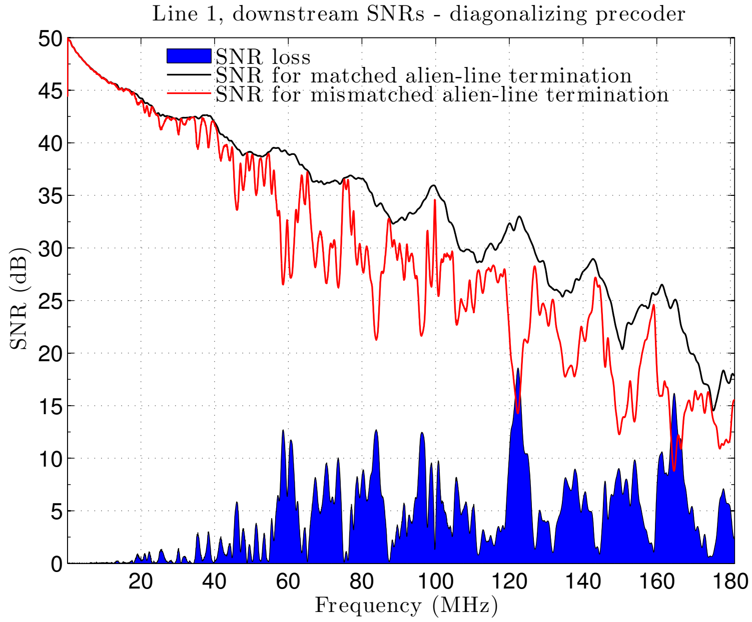

Figure 3: Impact of alien-line impedance mismatch: the drop in receive SNR (shaded blue area) when changing the alien-line termination from 100 Ohm (solid black line) to open (solid red line) can be significant. (Example for line no. 1 in a 2-line vectored group transmitting over a 100 m 30-pair cable.)

be controlled or monitored and are thus referred to as *alien lines*. Two problems arise: First, the loss in SNR is tremendous for wide portions of the used band, which reduces spectral efficiency. Second, and more importantly, the SNR changes by far exceed feasible safety margins that could be introduced to account for non-stationary channel effects. Traditional remedies such as stronger coding, SNR margins, or retransmission schemes fail and a sudden channel change of that magnitude will jeopardize system stability.

Earlier work [28, 31–35] laid the necessary foundations for multi-conductor transmission line modeling this project is capitalizing on. A first hint towards sparsity and an idea of a corresponding model reflecting the sparsity property in matrix wireline channels is under investigation [25]. A non-model-based slow channel tracking algorithm using the least-squares approach, which has been studied in [21], clearly emphasized the need for and the potential of faster tracking approaches exploiting structural channel knowledge. First results on a system-level approach to model-based control of the vectoring engine have revealed tremendous improvements in minimizing the duration-of-impact of a sudden channel change [29].

References

[1] V. Oksman, H. Schenk, A. Clausen, J. M. Cioffi, M. Mohseni, G. Ginis, C. Nuzman, J. Maes, M. Peeters, K. Fisher, and P.-E. Eriksson, “The ITU-T’s new G.vector standard proliferates 100 Mb/s DSL,” *IEEE Communications Magazine*, vol. 48, no. 10, pp. 140–148, Oct. 2010.

[2] P. Ödling, T. Magesacher, S. Höst, P. O. Börjesson, M. Berg, and E. Areizaga, “The fourth generation broadband concept,” *IEEE Communications Magazine*, vol. 47, no. 1, pp. 62–69, Jan. 2009.

[3] J. Hoydis, M. Kobayashi, and M. Debbah, "Green small-cell networks," *Vehicular Technology Magazine, IEEE*, vol. 6, no. 1, pp. 37–43, 2011.

[4] J. Gambini and U. Spagnolini, "Radio over telephone lines in femtocell systems," in *Proc. 2010 IEEE 21st International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC)*, Sept 2010, pp. 1544–1549.

[5] J. Gambini, S. Savazzi, P. Castiglione, U. Spagnolini, and G. Matz, "Wireless over cable in femtocell systems: A case study from indoor channel measurements," in *Proc. 2012 IEEE Wireless Communications and Networking Conference Workshops (WCNCW)*, April 2012, pp. 137–141.

[6] Kee Bong Song, Seong Taek Chung, G. Ginis, and J. M. Cioffi, "Dynamic spectrum management for next-generation DSL systems," *IEEE Communications Magazine*, vol. 40, no. 10, pp. 101–109, Oct. 2002.

[7] G. Ginis and J. M. Cioffi, "Vectored transmission for digital subscriber line systems," *IEEE Journal on Selected Areas in Communications*, vol. 20, no. 5, pp. 1085–1104, June 2002.

[8] R. Cendrillon, M. Moonen, J. Verlinden, T. Bostoen, and G. Ginis, "Improved linear crosstalk precompensation for DSL," in *Proc. IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), 2004*, Montreal, Quebec, Canada, May 2004, vol. 4, pp. 1053–1056.

[9] R. Cendrillon, M. Moonen, E. Van den Bogaert, and G. Ginis, "The linear zero-forcing crosstalk canceler is near-optimal in DSL channels," in *Proc. IEEE Global Telecommunications Conference (GLOBECOM 2004)*, Dallas, TX, USA, Nov.–Dec. 2004, vol. 4, pp. 2334–2338.

[10] R. Cendrillon, M. Moonen, G. Ginis, K. Van Acker, T. Bostoen, and P. Vandaele, "Partial crosstalk cancellation for upstream VDSL," *EURASIP J. Appl. Signal Process.*, vol. 2004, no. 10, pp. 1520–1535, Jan. 2004.

[11] R. Cendrillon, G. Ginis, M. Moonen, and K. Van Acker, "Partial crosstalk precompensation in downstream VDSL," *Signal Process.*, vol. 84, no. 11, pp. 2005–2019, Nov. 2004.

[12] T. Magesacher, J. Rius i Riu, P. Ödling, P. O. Börjesson, M. Tilocca, and M. Valentini, "Limits of ultra-wideband communication over copper," in *Proc. International Conference on Communication Technology (ICCT) 2006*, Guilin, China, Nov. 2006, pp. 1–4.

[13] W. Foubert, C. Neus, L. Van Biesen, and Y. Rolain, "Exploiting the phantom-mode signal in DSL applications," *IEEE Transactions on Instrumentation and Measurement*, vol. 61, no. 4, pp. 896–902, Apr. 2012.

[14] T. Magesacher, P. Ödling, P. O. Börjesson, W. Henkel, T. Nordström, R. Zukunft, and S. Haar, "On the capacity of the copper cable channel using the common mode," in *Proc. IEEE Global Telecommunications Conference (GLOBECOM) 2002*, Taipei, Taiwan, Nov. 2002, vol. 2, pp. 1269–1273.

[15] J. M. Cioffi, S. Jagannathan, M. Mohseni, and G. Ginis, "CuPON: the copper alternative to PON 100 Gb/s DSL networks," *IEEE Communications Magazine*, vol. 45, no. 6, pp. 132–139, Jun. 2007.

[16] S. Jagannathan, V. Pourahmad, K. Seong, J. M. Cioffi, M. Ouzzif, and R. Tarafi, "Common-mode data transmission using the binder sheath in digital subscriber lines," *IEEE Transactions on Communications*, vol. 57, no. 3, pp. 831–840, Mar. 2009.

[17] TNO, "G.fast: Vectoring Gain Limitations due to Changing Terminations of Alien Wire Pairs," ITU-T SG15 contribution 2013-03-q4-044, Mar. 2013.

[18] Alcatel-Lucent, "G.fast: Influence of an Impedance Change on a Leaving Line onto the Direct and Crosstalk Channels of the Active Lines," ITU-T SG15 contribution 2013-10-q4-058, Oct. 2013.

[19] Futurewei Technologies, "G.fast: SNR Drop and FEXT Channel Variations due to Change of Alien Termination," ITU-T SG15 contribution 2013-10-q4-046, Oct. 2013.

[20] E. Medeiros, T. Magesacher, P.E. Eriksson, C. Lu, P. Ödling, and D. Statovci, "G.fast: Impact of alien-line termination changes on vectoring performance," *ITU-T SG15 Temporary Document 2013-10-Q4-028*, Oct. 2013, Ipswich, UK.

[21] E. Medeiros, T. Magesacher, P.-E. Eriksson, C. Lu, and P. Ödling, "How vectoring in G.fast may cause neighborhood wars," in *Proc. 2014 IEEE International Conference on Communications (ICC)*, June 2014, pp. 3859–3864.

[22] C. Lu and P.-E. Eriksson, "A fast channel estimation method for disorderly leaving events in vectored DSL systems," in *Proc. 2011 IEEE International Conference on Communications (ICC)*, June 2011, pp. 1–6.

[23] "Self-FEXT Cancellation (Vectoring) for Use with VDSL2 Transceivers - Corrigendum 1," Recommendation, International Telecommunication Union, June 2011.

[24] "Self-FEXT Cancellation (Vectoring) for Use with VDSL2 Transceivers," Recommendation, International Telecommunication Union, Sept. 2010.

[25] E. Medeiros, T. Magesacher, P. Ödling, D. Wei, X. Wang, Q. Li, P.-E. Eriksson, C. Lu, J. Boschma, and B. van den Heuvel, "Modeling alien-line impedance mismatch in wideband vectored wireline systems," *IEEE Communications Letters*, vol. 18, no. 9, pp. 1527–1530, Sept 2014.

[26] Clayton R. Paul, *Analysis of Multiconductor Transmission Lines*, ISBN 0-471-02080-X, Wiley, 1994.

[27] D.A. Frickey, "Conversions between S, Z, Y, h, ABCD, and T parameters which are valid for complex source and load impedances," *IEEE Transactions on Microwave Theory and Techniques*, vol. 42:2, pp. 205–211, Feb 1994.

[28] T. Magesacher, "MTL—A multi-wire transmission line modeling toolbox," *International Journal of Computer and Electrical Engineering*, vol. 5, no. 1, pp. 52–55, Feb. 2013.

[29] Y. Huang, T. Magesacher, E. Medeiros, C. Lu, P.-E. Eriksson, and P. Ödling, "Mitigating disorderly leaving events in G.fast," to appear in *Proc. 2015 IEEE International Conference on Communications (ICC)*, June 2015.

[30] Lund University and Ericsson AB, "G.fast: Impact of Alien-Line Termination Changes on Vectoring Performance," ITU-T SG15 contribution 2013-10-q4-028, Oct. 2013.

[31] T. Magesacher, W. Henkel, G. Tauböck, and T. Nordström, "Cable measurements supporting xDSL technologies," *Journal e&i Elektrotechnik und Informationstechnik*, vol. 199, no. 2, pp. 37–43, Feb. 2002.

[32] T. Magesacher, P. Ödling, P.O. Börjesson, and S. (Shitz) Shamai, "Information rate bounds in common-mode aided wireline communications," *European Transactions on Telecommunications (ETT)*, DOI: 10.1002/ett.1073, published online: 1 Sept. 2005.

[33] T. Magesacher, P. Ödling, P.O. Börjesson, and T. Nordström, "Verification of multi-pair copper cable model by measurements," *IEEE Transactions on Instrumentation and Measurement*, vol. 56, no. 5, pp. 1883–1886, Oct. 2007.

[34] F. Lindqvist, N. Lindqvist, B. Dortschy, P. Ödling, P.O. Börjesson, K. Ericson, and E. Pelaes, "Crosstalk channel estimation via standardized two-port measurements," *Eurasip Journal on Advances in Signal Processing*, vol. 2008, 2008.

[35] T. Magesacher, "MTL: A MATLAB toolbox for multi-wire transmission line modeling," CELTIC project 4GBB, 2011, Available by email-request to `tom@eit.lth.se`.

Interdisciplinarity

My application is interdisciplinary

☐

An interdisciplinary research project is defined in this call for proposals as a project that can not be completed without knowledge, methods, terminology, data and researchers from more than one of the Swedish Research Councils subject areas; Medicine and health, Natural and engineering sciences, Humanities and social sciences and Educational sciences. If your research project is interdisciplinary according to this definition, you indicate and explain this here.

Click here for more information

Scientific report

Scientific report/Account for scientific activities of previous project

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Budget and research resources

Project staff

Describe the staff that will be working in the project and the salary that is applied for in the project budget. Enter the full amount, not in thousands SEK.

Participating researchers that accept an invitation to participate in the application will be displayed automatically under Dedicated time for this project. Note that it will take a few minutes before the information is updated, and that it might be necessary for the project leader to close and reopen the form.

Dedicated time for this project

	Role in the project	Name	Percent of full time
1	Applicant	Thomas Magesacher	5
2	Participating researcher	Yezi Huang	85
3	Participating researcher	Eduardo Medeiros	20

Salaries including social fees

	Role in the project	Name	Percent of salary	2016	2017	Total
1	Applicant	Thomas Magesacher	5	47,290	48,708	95,998
2	Participating researcher	Yezi Huang	80	385,735	397,307	783,042
3	Participating researcher	Eduardo Medeiros	20	96,434	99,327	195,761
	Total			529,459	545,342	1,074,801

Other costs

Describe the other project costs for which you apply from the Swedish Research Council. Enter the full amount, not in thousands SEK.

Premises

Type of premises	2016	2017

Running Costs

Running Cost	Description	2016	2017

Depreciation costs

Depreciation cost	Description	2016	2017

Total project cost

Below you can see a summary of the costs in your budget, which are the costs that you apply for from the Swedish Research Council. Indirect costs are entered separately into the table.

Under Other costs you can enter which costs, aside from the ones you apply for from the Swedish Research Council, that the project includes. Add the full amounts, not in thousands of SEK.

The subtotal plus indirect costs are the total per year that you apply for.

Total budget

Specified costs	2016	2017	Total, applied	Other costs	Total cost
Salaries including social fees	529,459	545,342	1,074,801	56,000	1,130,801
Running costs			0		0
Depreciation costs			0		0
Premises			0		0
Subtotal	529,459	545,342	1,074,801	56,000	1,130,801
Indirect costs	222,372	229,044	451,416		451,416
Total project cost	751,831	774,386	1,526,217	56,000	1,582,217

Explanation of the proposed budget

Briefly justify each proposed cost in the stated budget.

Explanation of the proposed budget*

Trips (14000kr/year): International scientific exchange and dissemination of results involves the participation in conferences and workshops.

Equipment (28000kr): Apart form standard personal computer equipment, no extra equipment is required.

Other funding

Describe your other project funding for the project period (applied for or granted) aside from that which you apply for from the Swedish Research Council. Write the whole sum, not thousands of SEK.

Other funding for this project

Funder	Applicant/project leader	Type of grant	Reg no or equiv.	2016	2017

CV and publications

CV

CV of Thomas Magesacher

Personal data

Born:	7 May 1974 in Friesach, Austria
Nationality:	Austrian
Office Address:	Lund University, Box 118, 221 00 Lund
Tel. (mobile):	+46 70 3841636
Tel. (office):	+46 46 2227579
Email:	thomas.magesacher@eit.lth.se

1. Undergraduate exam: 1998-06-20, Telecommunications, *Graz University of Technology*, Austria

2. Doctoral exam: 2006-09-28, Signal Processing, *Lund University*, Sweden

3. Post-doctoral visits: April 2007–March 2008, *Stanford University*, USA

4. Docent competence: 2011-09-02, Telecommunications, *Lund University*, Sweden

5. Current employment: Associate professor at the *Department of Electrical and Information Technology, Lund University*, Sweden

6. Previous employment:

Apr 2008 – Sep 2011	Assistant professor at the *Department of Information Technology, Lund University, Sweden*.
Apr 2007 – Mar 2008	Post doctoral fellow at the *Deptartment of Electrical Engineering, Stanford University, Stanford, USA*.
Jan 2004 – Mar 2007	Researcher and PhD student at the *Department of Information Technology, Lund University, Sweden*.
since Jan 2003	Consultant for *Ericsson AB, Stockholm, Sweden*.
Feb 2003 – Dec 2003	Researcher at the *Department of Electroscience, Lund University, Sweden*.
Nov 2002 – Dec 2002	Guest lecturer at the *Department of Electroscience, Lund University, Sweden*.
Jan 2002 – May 2002	Guest researcher and lecturer at the *Department of Electroscience, Lund University, Sweden*.
Aug 2000 – Jan 2003	Researcher in the area of information processing at the *Telecommunications Research Center Vienna (ftw.), Austria*.
Jul 1997 – May 2002	Concept engineer in the field of wireline and cable transmission systems with *Infineon Technologies, Austria*.

7. Interruption of research:

Nov 2014 – Mar 2015 Parental leave

8. Supervision of PhD students: -

- Main supervisor of *Yezi Huang, Lund University, Sweden*
- Co-supervisor of *Eduardo Medeiros, Lund University, Sweden*
- Co-supervisor of *Marcio Monteiro, Lund University, Sweden*
- Co-supervisor of *Fredrik Lindqvist, Lund University, Sweden*
- Co-supervisor of *Miloš Jakovljević, Ciudad Universitaria, Madrid, Spain*

9. Merits/distinctions:

- IEEE Communications Society 2014 TAOS Best Paper Award in Access Networks and Systems
- Best Paper Award IEEE ICC 2014 - Symposia Paper
- awarded *9-month industry/academia-mobility grant* in 2012 from the Swedish Foundation for Strategic Research (grant No. SM12-0050, 700 kSEK)
- Ingvar Carlsson Award 2009 *3-year project grant* from the Swedish Foundation for Strategic Research (grant No. ICA08-0022, 3 MSEK)
- awarded *3-year project grant* in 2008 from the Swedish Research Council (grant No. 621-2008-4139, 1.8 MSEK)
- awarded *junior research grant* from the Swedish Research Council in 2007 (grant No. 621-2007-6309)
- awarded *post doctoral grant* from the Swedish Research Council in 2006 (grant No. 623-2006-5121)
- *senior member of the IEEE* since 2011
- *member of the editorial board* of the ELSEVIER International Journal on Electronics and Communications, 2007–2012
- *member of the technical program committee* of the IEEE Global Communications Conference GLOBECOM'08

10. Citations indexes: Thomas Magesacher has h-index 9 and g-index 16 based on data from Google Scholar. The numbers of citations of the 16 most-cited publications are 65, 28, 27, 24, 22, 15, 15, 15, 14, 8, 8, 8, 8, 7, 7, 7.

***11. Collaboration:* (selection)**

- *John M. Cioffi*, Professor at the Department of Electrical Engineering, Stanford University, CA, USA
- *Lajos Gazsi*, Professor at Ruhr Universität Bochum, Bochum, Germany and Fellow with Infineon Technologies AG, Germany
- *Stephen McLaughlin*, Professor at the Institute for Digital Communications, Signals and Systems Group, University of Edinburgh, Scotland, UK
- *Marc Moonen*, Professor at the Department of Electrical Engineering, University of Leuven, Belgium
- *Shlomo Shamai*, Professor at the Department of Electrical Engineering, Israel Institute of Technology, Haifa, Israel

CV of Per Ola Börjesson

Personal data

Born: Sep 1945 in Karlshamn, Sweden
Nationality: Swedish
Office Address: Lund University, Box 118, 221 00 Lund
Tel. (mobile): +46 70 5590344
Tel. (office): +46 46 2223446
Email: per.ola.borjesson@eit.lth.se
Home page: http://www.eit.lth.se/staff/per_ola.borjesson

1. Undergraduate exam: Civilingenjör (MSc) in Electrical Engineering/Electrical Measurements, 1970.

2. Doctoral exam: Ph.D. in Telecommunication Theory, Lund University, 1980.

3. Post-doctoral visits: -

4. Docent competence: Docent in Telecommunication Theory, Lund University, 1983.

5. Current employment: Senior Professor of Signal Processing at the *Department of Electrical and Information Technology, Lund University, Lund*, 2012–, 20% active in research.

6. Previous employment:

1998 – 2012 Professor of Signal Processing at *Lund University*, Lund.

1988 – 1998 Professor of Signal Processing at *Luleå University of Technology*, Luleå.

1987 – 1988 Consulting engineer, working with research, development and education.

1985 – 1986 Established and was the Managing Director of *Elektronikcentrum i Svängsta AB*, Svängsta.

1982 – 1985 Designer and Project Director at *Facit AB / Ericsson AB*, Svängsta.

1979 – 1982 Developed biomedical measurement and signal processing systems for the *Department of Biomedical Engineering at Malmö General Hospital*, Malmö.

1972 – 1979 Teaching and Research Assistant at the *Lund University*, Lund.

1970 – 1972 Working with theoretical aspects of radar and laser systems at *L.M. Ericsson*, Mölndal.

7. Interruption of research: -

8. Examined PhD candidates (year of disputation, name):

1993 Lennart Olsson *

1993 Kalevi Hyyppä *

1995 Per Ödling*

1995 Håkan B. Eriksson*

1995 Sven Nordebo*

1996 Magnus Sandell*

1996 Ove Edfors*

1997 Jan-Olof Gustavsson*

1998 Jan-Jaap van de Beek*

2004 Daniel Landström **

2005 Niklas Andgart **

2006 Thomas Magesacher **

2012 Fredrik Lindqvist **

*) with Per Ola Börjesson as Main Supervisor.

**) From 1999 and ahead all the Ph.D. candidates of Per Ola Börjesson have Per Ödling as Main Supervisor and Per Ola Börjesson as assistant supervisor. Per Ola Börjesson also has the role as a mentor for other supervisors.

9. Articles with high citations: The articles [1] and [2] are groundbreaking works concerning synchronization and channel estimation for OFDM systems, published several years before the scientific area got the attention it has today. Due to the works' relevance for the 4G-system, these articles are now frequently cited: 2347 and 1580 times respectively according to Google Scholar. The synchronization article, [1], has been among the ”Top Accessed Documents for the Month” in Transaction on Signal Processing for at least a year.

10. Citations indexes: Per Ola Börjesson has h-index 24 and g-index 91 based on data from Google Scholar. The numbers of citations of the 24 most-cited publications based on Google Scholar are 2347, 1580, 1535, 431, 286, 250, 200, 160, 146, 119, 104, 96, 78, 69, 65, 60, 46, 43, 36, 33, 28, 26, 25, 24.

References

[1] J.-J. van de Beek, M. Sandell, and P. O. Börjesson, “ML estimation of time and frequency offset in OFDM systems,” *IEEE Transactions on Signal Processing*, vol. 45, no. 7, pp. 1800–1805, 1997, Cited By (Google Scholar): 2347.

[2] O. Edfors, M. Sandell, J.-J. Van Beek, S. K. Wilson, and P. O. Börjesson, “OFDM channel estimation by singular value decomposition,” *IEEE Transactions on Communications*, vol. 46, no. 7, pp. 931–939, 1998, Cited By (Google Scholar): 1580.

Publication list

Publications of Thomas Magesacher

h-index: 9
g-index: 16

Citation-count source: Google Scholar.

Please note:

- Publications older than 8 years are not included unless they are among the five most cited publications ([J3],[C21],[J8],[C19],[J9]) or impact the h-/g-index.
- The five most relevant publications to this application are marked with *.

1. Refereed journal papers

* [J1] E. Medeiros, T. Magesacher, P. Ödling, D. Wei, X. Wang, Q. Li, P.-E. Eriksson, C. Lu, J. Boschma, and B. van den Heuvel, "Modeling alien-line impedance mismatch in wideband vectored wireline systems," *IEEE Communications Letters*, vol. 18, no. 9, pp. 1527–1530, Sept 2014.

[J2] T. Magesacher and E. Trojer, "Single-kernel fast fourier transform processing for time-division duplexing-discrete multi-tone," *Advanced Science Letters*, vol. 8, no. 8, pp. 2515–2518, Aug. 2013.

[J3] T. Magesacher, "MTL—A multi-wire transmission line modeling toolbox," *International Journal of Computer and Electrical Engineering*, vol. 5, no. 1, pp. 52–55, Feb. 2013.

* [J4] P. Ödling, T. Magesacher, S. Höst, P.O. Börjesson, M. Berg, and E. Areizaga, "The fourth generation broadband concept," *IEEE Communications Magazine*, vol. 47, no. 1, pp. 62–69, Jan. 2009, Number of citations: 65, most cited.

[J5] T. Magesacher, P. Ödling, P.O. Börjesson, and T. Nordström, "Verification of multi-pair copper cable model by measurements," *IEEE Transactions on Instrumentation and Measurement*, vol. 56, no. 5, pp. 1883–1886, Oct. 2007, Number of citations: 7.

[J6] T. Magesacher, "Spectral compensation for multicarrier communication," *IEEE Transactions on Signal Processing*, vol. 55, no. 7, pp. 3366–3379, July 2007, Number of citations: 8.

[J7] T. Magesacher, P. Ödling, and P.O. Börjesson, "Analysis of adaptive interference cancellation using common-mode information in wireline communications," *EURASIP Journal on Advances in Signal Processing*, Article ID 84956, 11 pages, doi:10.1155/2007/84956, 2007, Number of citations: 14.

* [J8] T. Magesacher, P. Ödling, P.O. Börjesson, and S. (Shitz) Shamai, "Information rate bounds in common-mode aided wireline communications," *European Transactions on Telecommunications (ETT)*, DOI: 10.1002/ett.1073, published online: 1 Sept. 2005, Number of citations: 15.

[J9] P. Ödling, P.O. Börjesson, T. Magesacher, and T. Nordström, "An approach to analog mitigation of RFI," *IEEE Journal on Selected Areas in Communication*, vol. 20, no. 5, pp. 974–986, June 2002, Number of citations: 27, 3rd most cited.

* [J10] T. Magesacher, W. Henkel, G. Tauböck, and T. Nordström, "Cable measurements supporting xDSL technologies," *Journal e&i Elektrotechnik und Informationstechnik*, vol. 199, no. 2, pp. 37–43, Feb. 2002, Number of citations: 22, 5th most cited.

2. Refereed conference contributions

[C1] Y. Huang, T. Magesacher, E. Medeiros, C. Lu, P.-E. Eriksson, and P. Ödling, "Mitigating disorderly leaving events in G.fast," to appear in *Proc. 2015 IEEE International Conference on Communications (ICC)*, June 2015.

[C2] Y. Huang, S. Medeiros, E. Höst, T. Magesacher, P.-E. Eriksson, C. Lu, P. Ödling, and P.O. Börjesson, "Enabling DSL and radio on the same copper pair," to appear in *Proc. 2015 IEEE International Conference on Communications (ICC)*, June 2015.

* [C3] E. Medeiros, T. Magesacher, P.-E. Eriksson, C. Lu, and P. Ödling, "How vectoring in G.fast may cause neighborhood wars," in *Proc. 2014 IEEE International Conference on Communications (ICC)*, June 2014, pp. 3859–3864.

[C4] D. Statovic, T. Magesacher, M. Wolkerstorfer, and E. Medeiros, "Analysis of fast initialization for vectored wireline systems," in *Proc. IEEE Global Telecommun. Conf. GLOBECOM 2013*, Atlanta, GA, USA, Dec. 2013.

[C5] T. Magesacher, D. Statovic, T. Nordström, and E. Riegler, "Performance analysis of vectored wireline systems embracing channel uncertainty," in *Proc. IEEE Intl. Conference on Communications ICC'13*, Budapest, Hungary, June 2013.

[C6] M. Vázquez and T. Magesacher, "Versatile low PAPR and low out-of-band power OFDM system," in *Proc. 16th Intl. OFDM-Workshop InOWo'11*, Hamburg, Germany, Aug. 2011, pp. 323–327.

[C7] T. Magesacher and J.M. Cioffi, "On minimum peak-to-average power ratio spectral factorization," in *Proc. 8th International Workshop on Multi-Carrier Systems & Solutions (MC-SS 2011)*, May 2011, pp. 1–4.

[C8] F. Lindqvist, P.O. Börjesson, P. Ödling, S. Höst, K. Ericson, and T. Magesacher, "Low-order and causal twisted-pair cable modeling by means of the Hilbert transform," in *AIP Conference Proceedings*, 2009, vol. 1106, pp. 301–310, Number of citations: 3.

[C9] M. Jakovljevic, T. Magesacher, P. Ödling, P. O. Börjesson, M. Sanchez, and S. Zazo, "Throughput of shielded twisted-pair cables using wire-shield modes in the presence of radio ingress," in *DSP'09: Proceedings of the 16th International Conference on Digital Signal Processing*, Piscataway, NJ, USA, 2009, pp. 1289–1294, IEEE Press, Number of citations: 3.

[C10] M. Jakovljević, T. Magesacher, K. Ericson, P. Ödling, P.O. Börjesson, and S. Zazo, "Common mode characterization and channel model verification for shielded twisted pair (STP) cable," in *Proc. Intl. Conference on Communications ICC'08*, Beijing, China, May 2008, Number of citations: 8.

[C11] M. Malkin, T. Magesacher, and J.M. Cioffi, "Dynamic allocation of reserved tones for PAR reduction," in *Proc. 13th Intl. OFDM-Workshop InOWo'08*, Hamburg, Germany, Aug. 2008, Number of citations: 1.

[C12] T. Magesacher, P. Ödling, and P.O. Börjesson, "On time-domain guard-interval nulling for PSD-constrained channels," in *Proc. 12th Intl. OFDM-Workshop InOWo'07*, Hamburg, Germany, Aug. 2007, pp. 128–131.

[C13] J. Rius i Riu, J. Rosenberg, F. Lindqvist, M. Tilocca, C. Bianco, B. van den Heuvel, P. Ödling, T. Magesacher, M. Berg, J. Sorio, A. Uvliden, and P.O. Börjesson, "The IST-MUSE approach to DSL loop qualification and monitoring," in *Proc. 3rd Broadband Europe Conference*, Geneva, Switzerland, Dec. 2006, Number of citations: 3.

[C14] T. Magesacher, J. Rius i Riu, P. Ödling, P.O. Börjesson, M. Tilocca, and M. Valentini, "Limits of ultra-wideband communication over copper," in *Proc. Intl. Conference on Communication Technology ICCT 2006*, Guilin, China, Nov. 2006, Number of citations: 2.

[C15] T. Magesacher, J. Rius i Riu, M. Jakovljević, M. Loiola, P. Ödling, and P.O. Börjesson, "Measurement and modeling of short copper cables for ultra-wideband communications," in *Proc. SPIE OpticsEast Broadband Access Communication Technologies*, Boston, MA, USA, Oct. 2006, Number of citations: 4.

[C16] T. Magesacher, P. Ödling, and P.O. Börjesson, "A fair comparison of transmitter-based spectral shaping techniques," in *Proc. 11th Intl. OFDM-Workshop InOWo'06*, Hamburg, Germany, Aug. 2006, pp. 323–327, Number of citations: 2.

[C17] T. Magesacher, P. Ödling, and P.O. Börjesson, "Optimal intersymbol transmit windowing for multicarrier modulation," in *Proc. 6th Nordic Signal Processing Symp. NORSIG 2006,* Reykjavik, Iceland, Reykjavik, Iceland, June 2006, Number of citations: 7.

[C18] T. Magesacher, "Optimal intra-symbol transmit windowing for multicarrier modulation," in *Proc. Intl. Symp. on Communications, Control and Signal Processing ISCCSP 2006*, Marrakech, Morocco, Mar. 2006.

[C19] T. Magesacher, P. Ödling, and P.O. Börjesson, "Optimal intra-symbol spectral compensation for multicarrier modulation," in *Proc. Intl. Zurich Seminar on Broadband Communications IZS 2006*, Zurich, Switzerland, Feb. 2006, pp. 138–141, Number of citations: 7.

[C20] T. Magesacher, P. Ödling, and P.O. Börjesson, "Adaptive interference cancellation using common-mode information in DSL," in *Proc. European Signal Processing Conf. EUSIPCO 2005*, Antalya, Turkey, Sept. 2005, Number of citations: 15.

[C21] T. Magesacher, P. Ödling, P.O. Börjesson, and T. Nordström, "Exploiting the common-mode signal in xDSL," in *Proc. European Signal Processing Conf. EUSIPCO 2004*, Vienna, Austria, Sept. 2004, Number of citations: 24, 4th mosted cited.

[C22] T. Magesacher, P. Ödling, J. Sayir, and T. Nordström, "Capacity of an extension of Cover's two-look Gaussian channel," in *Proc. Intl. Symp. on Information Theory ISIT 2003*, Yokohama, Japan, June 2003, p. 262, Number of citations: 8.

[C23] T. Magesacher, P. Ödling, P.O. Börjesson, W. Henkel, T. Nordström, R. Zukunft, and S. Haar, "On the capacity of the copper cable channel using the common mode," in *Proc. IEEE Global Telecommun. Conf. GLOBECOM 2002*, Taipei, Taiwan, Nov. 2002, Number of citations: 28, 2nd most cited.

[C24] S. Haar, D. Daecke, R. Zukunft, and T. Magesacher, "Equalizer-Based Symbol-Rate Timing Recovery for Digital Subscriber Line Systems," in *Proc. IEEE Global Telecommun. Conf. GLOBECOM 2002*, Taipei, Taiwan, Nov. 2002, Number of citations: 6.

[C25] T. Magesacher, P. Ödling, T. Nordström, T. Lundberg, M. Isaksson, and P.O. Börjesson, "An adaptive mixed-signal narrowband interference canceller for wireline transmission systems," in *Proc. IEEE Intl. Symp. Circuits and Systems ISCAS 2001*, Sydney, Australia, May 2001, Number of citations: 15.

3. Overview articles, book chapters, books

[O1] T. Magesacher, P. Ödling, P.O. Börjesson, S. Höst, E. Areizaga, M. Berg, and E. Jacob, "Paving the road to Gbit/s broadband access with copper," chapter in the book *"Convergence of Mobile and Stationary Next-Generation Networks, WILEY, ISBN 978-0-470-54356-6*, 2010.

[O2] T. Magesacher, J. Lee, P. Ödling, and P.O. Börjesson, "Synchronization for OFDMA," chapter in the book *"Orthogonal Frequency Division Multiple Access Fundamentals and Applications", AUERBACH, ISBN 978-1-4200882-4-3*, 2010.

[O3] T. Magesacher, "Spectrally efficient OFDMA," chapter in the book *"Orthogonal Frequency Division Multiple Access Fundamentals and Applications", AUERBACH, ISBN 978-1-4200882-4-3*, 2010.

[O4] T. Magesacher, "Egress reduction for OFDM via transmit windowing—framework and comparison," *Lecture Notes Electrical Engineering: Multi-Carrier Systems and Solutions 2009, ISBN 978-90-481-2529-6*, vol. 41, pp. 365–373, May 2009.

[O5] T. Magesacher, *OFDM for broadband communication*, class reader, course code: EIT140, Lund University, ISBN 91-7167-036-X, 2005.

4. Patents

[P1] P.-E. Eriksson, Y. Huang, C. Lu, T. Magesacher, and E. Medeiros, "Method and arrangement in a dsl vectoring system," *patent application, PCT/SE2014/051135*, 2014.

[P2] M. Berg, P.-E. Eriksson, C. Lu, T. Magesacher, and E. Trojer, "Spectrum shaping for OFDM/DMT," *patent application, PCT/EP2013/059625*, 2013.

[P3] T. Magesacher and E. Trojer, "Baseband processing of TDD signals via size-N FFT," *patent application, PCT/SE2012/050743*, 2012.

[P4] T. Magesacher and E. Trojer, "Baseband processing of TDD signals via size-$N/2$ FFT," *patent application, PCT/SE2012/050744*, 2012.

[P5] J. Rius i Riu, T. Magesacher, and P. Ödling, "Precoder for a communication system and methods used in said communication system," *WO Patent WO/2010/021,575*, 2010.

5. Software

[S1] T. Magesacher, "Spectral factorization toolbox `spectfact`," MATLAB© toolbox, 2012, available per request from `tom@eit.lth.se`.

[S2] T. Magesacher, "MTL: A MATLAB toolbox for multi-wire transmission line modeling," CELTIC project 4GBB, 2011, available per request from `tom@eit.lth.se`.

[S3] T. Magesacher, "SPECSHAPE: A MATLAB toolbox for spectral shaping of multicarrier transmit signals," Lund University, Lund, Sweden, 2006, available per request from `tom@eit.lth.se`.

6. Popular science contributions

[U1] T. Magesacher, P. Ödling, and P.O. Börjesson, "Capacity of the Swedish copper access network," in *Proc. Radio Vetenskap RVK 2005*, Linköping, Sweden, June 2005.

7. Miscellaneous

[M1] E. Medeiros, T. Magesacher, P.E. Eriksson, C. Lu, P. Ödling, and D. Statovci, "G.fast: Impact of alien-line termination changes on vectoring performance," *ITU-T SG15 Temporary Document 2013-10-Q4-028*, Oct. 2013, Ipswich, UK.

[M2] F. Lindqvist, P.O. Börjesson, P. Ödling, K. Ericson, S. Höst, and T. Magesacher, "Low-order and causal twisted-pair cable modeling by means of the Hilbert transform," in *Proc. Twentieth Nordic Conference on Radio Science and Communications RVK'08*, Växjö, Sweden, June 2008.

[M3] T. Magesacher, *Common-Mode Aided Wireline Communications*, Ph.D. Thesis, Department of Information Technology, Lund University, Sweden, ISBN 91-7167-041-6, ISRN LUTEDX/TEIT-06/1037-SE, Sept. 2006, Number of citations: 5.

[M4] T. Magesacher, *Narrowband-Interference Mitigation on Digital Subscriber Lines*, Licentiate Thesis, Department of Information Technology, Lund University, Lund, Sweden, ISBN 91-7167-037-8, ISRN LUTEDX/TEIT-05/1033-SE, Oct. 2005.

[M5] E. Trojer, P.E. Eriksson, and T. Magesacher, “G.fast: Low complexity FFT/IFFT scheme,” *ITU-T SG15 contribution 2355 (Q4A/15)*, Aug. 2012, Geneva, Switzerland.

[M6] T. Magesacher and T. Nordström, “Longitudinal signals in DSL: Review and test proposal,” *Temporary Document TD 06, 053t06, ETSI STC TM6*, Sept. 2005, Gent, Belgium.

[M7] T. Magesacher, W. Henkel, T. Nordström, P. Ödling, and P.O. Börjesson, “On the correlation between common-mode and differential-mode signals,” *Temporary Document TD 45, 013t45, ETSI STC TM6*, Sept. 2001, Stockholm, Sweden.

[M8] T. Magesacher, “On evolution and complexity of A/D converters for VDSL,” *ITU-T SG15 contribution D.625 (WP1/15)*, June 1999, Geneva, Switzerland.

Publications of Per Ola Börjesson

h-index: 24
g-index: 91

Citation-count source: Google Scholar.

Please note:

- Publications older than 8 years are not included unless they are among the five most cited publications ([J16],[C19],[J15],[J13],[C20]) or impact the h-index.
- The five most relevant publications to this application are marked with *.

1. Refereed journal papers

[J1] D. Acatauassu, S. Höst, C. Lu, M. Berg, A. Klautau, and P.O. Börjesson, "Simple and Causal Copper Cable Model Suitable for G.fast Frequencies," *IEEE Transactions on Communications*, vol. 62, no. 11, pp. 4040–4051, 2014.

[J2] A. Fertner, D. Cederholm, and P.O. Börjesson, "Determination of the propagation constant from single-ended line test data," *IEEE Transactions on Instrumentation and Measurement*, vol. 61, no. 9, pp. 2422–2427, 2012.

[J3] C. Sales, R.M. Rodrigues, F. Lindqvist, J. Costa, A. Klautau, K. Ericson, J. Rius i Riu, and P.O. Börjesson, "Line Topology Identification Using Multiobjective Evolutionary Computation," *IEEE Transactions on Instrumentation and Measurement*, vol. 59, no. 3, pp. 715–729, 2010, Number of citations: 11.

* [J4] P. Ödling, T. Magesacher, S. Höst, P.O. Börjesson, M. Berg, and E. Areizaga, "The fourth generation broadband concept," *IEEE Communications Magazine*, vol. 47, no. 1, pp. 62–69, Jan. 2009, Number of citations: 65.

* [J5] F. Lindqvist, N. Lindqvist, B. Dortschy, P. Ödling, P.O. Börjesson, K. Ericson, and E. Pelaes, "Crosstalk channel estimation via standardized two-port measurements," *Eurasip Journal on Advances in Signal Processing*, vol. 2008, 2008, Number of citations: 17.

* [J6] T. Magesacher, P. Ödling, P.O. Börjesson, and T. Nordström, "Verification of multi-pair copper cable model by measurements," *IEEE Transactions on Instrumentation and Measurement*, vol. 56, no. 5, pp. 1883–1886, Oct. 2007, Number of citations: 7.

[J7] T. Magesacher, P. Ödling, and P.O. Börjesson, "Analysis of adaptive interference cancellation using common-mode information in wireline communications," *EURASIP Journal on Advances in Signal Processing*, Article ID 84956, 11 pages, doi:10.1155/2007/84956, 2007, Number of citations: 14.

[J8] N. Andgart, P. Ödling, A. Johansson, and P.O. Börjesson, "Designing tone reservation PAR reduction," *EURASIP Journal on Applied Signal Processing*, Article ID 38237, 14 pages, doi:10.1155/ASP/2006/38237, 2006, Number of citations: 9.

* [J9] T. Magesacher, P. Ödling, P.O. Börjesson, and S. (Shitz) Shamai, "Information rate bounds in common-mode aided wireline communications," *European Transactions on Telecommunications (ETT)*, DOI: 10.1002/ett.1073, published online: 1 Sept. 2005, Number of citations: 15.

[J10] P. Ödling, P.O. Börjesson, T. Magesacher, and T. Nordström, "An approach to analog mitigation of RFI," *IEEE Journal on Selected Areas in Communication*, vol. 20, no. 5, pp. 974–986, June 2002, Number of citations: 27.

[J11] D. Landström, S.K. Wilson, J.J. van de Beek, P. Ödling, and P.O. Börjesson, "Symbol time offset estimation in coherent OFDM systems," *IEEE Transactions on Communications*, vol. 50, no. 4, pp. 545–549, 2002, Number of citations: 146.

[J12] O. Edfors, M. Sandell, J.-J. Van De Beek, S.K. Wilson, and P.O. Börjesson, "Analysis of DFT-based channel estimators for OFDM," *Wireless Personal Communications*, vol. 12, no. 1, pp. 55–70, 2000, Number of citations: 250.

[J13] J.-J. Van De Beek, P.O. Börjesson, M.-L. Boucheret, D. Landström, J.M. Arenas, P. Ödling, and S.K. Wilson, "Three non-pilot based time- and frequency estimators for OFDM," *Signal Processing*, vol. 80, no. 7, pp. 1321–1334, 2000, Number of citations: 23.

[J14] J.-J. Van De Beek, P.O. Börjesson, Boucheret M.-L., D. Landström, J.M. Arenas, P. Ödling, Östberg C., M. Wahlqvist, and S.K. Wilson, "Time and frequency synchronization scheme for multiuser OFDM," *IEEE Journal on Selected Areas in Communications*, vol. 17, no. 11, pp. 1900–1914, 1999, Number of citations: 431.

[J15] F. Sjöbeg, M. Isaksson, R. Nilsson, P. Ödling, S.K. Wilson, and P.O. Börjesson, "Zipper: a duplex method for VDSL based on DMT," *IEEE Transactions on Communications*, vol. 47, no. 8, pp. 1245–1252, 1999, Number of citations: 78.

[J16] O. Edfors, M. Sandell, J.-J. Van Beek, S.K. Wilson, and P.O. Börjesson, "OFDM channel estimation by singular value decomposition," *IEEE Transactions on Communications*, vol. 46, no. 7, pp. 931–939, 1998, Number of citations: 1535.

[J17] J.-J. Van De Beek, M. Sandell, and P.O. Börjesson, "ML estimation of time and frequency offset in OFDM systems," *IEEE Transactions on Signal Processing*, vol. 45, no. 7, pp. 1800–1805, 1997, Number of citations: 2347.

[J18] H. Eriksson, P.O. Börjesson, P. Ödling, and N.-G. Holmer, "Robust correlation receiver for distance estimation," *IEEE Transactions on Ultrasonics, Ferroelectrics, and Frequency Control*, vol. 41, no. 5, pp. 596–603, 1994, Number of citations: 24.

[J19] P.O. Börjesson, O. Pahlm, L. Sörnmo, and M.E. Nygards, "Adaptive QRS detection based on maximum a posteriori estimation," *IEEE Transactions on Biomedical Engineering*, vol. 29, no. 5, pp. 341–351, 1982, Number of citations: 52.

[J20] L. Sörnmo, P.O. Börjesson, M. Nygards, and O. Pahlm, "A method for evaluation of QRS shape features using a mathematical model for the ECG," *IEEE Transactions on Biomedical Engineering*, vol. 28, no. 10, pp. 713–717, 1981, Number of citations: 62.

[J21] P.O. Börjesson and C.-E. W. Sundberg, "Simple approximations of the error function q(x) for communications applications.," *IEEE Trans Commun*, vol. 27, no. 3, pp. 639–643, 1979, Number of citations: 160.

2. Refereed conference contributions

[C1] Y. Huang, S. Medeiros, E. Höst, T. Magesacher, P.-E. Eriksson, C. Lu, P. Ödling, and P.O. Börjesson, "Enabling DSL and radio on the same copper pair," to appear in *Proc. 2015 IEEE International Conference on Communications (ICC)*, June 2015.

[C2] D. Acatauassu, S. Höst, C. Lu, A. Klautau, and P.O. Börjesson, "Simple and Causal Twisted-Pair Channel Models for G.fast Systems," in *Proc. IEEE Global Telecommunications (GLOBECOM) 2013*, 2013.

[C3] S. Höst and F. Lindqvist and A. Fertner and K. Ericson and M. Berg and I. Pappa and P.O. Börjesson, "Low complexity computation of the BT0 Hilbert twisted pair cable model," *15th International OFDM-Workshop (InOWo'10)*, pp. 195–199, Hamburg, Germany, June 9-11, 2010-09-01.

* [C4] F. Lindqvist, P.O. Börjesson, P. Ödling, Höst S., K. Ericson, and T. Magesacher, "Low-order and causal twisted-pair cable modeling by means of the Hilbert transform," *AIP Conference Proceedings*, vol. 1106, pp. 301–310, 2009, Number of citations: 3.

[C5] M. Jakovljevic, T. Magesacher, P. Ödling, P. O. Börjesson, M. Sanchez, and S. Zazo, "Throughput of shielded twisted-pair cables using wire-shield modes in the presence of radio ingress," in *DSP'09: Proceedings of the 16th International Conference on Digital Signal Processing*, Piscataway, NJ, USA, 2009, pp. 1289–1294, IEEE Press, Number of citations: 3.

[C6] M. Jakovljević, T. Magesacher, K. Ericson, P. Ödling, P.O. Börjesson, and S. Zazo, "Common mode characterization and channel model verification for shielded twisted pair (STP) cable," in *Proc. Intl. Conference on Communications ICC'08*, Beijing, China, May 2008, Number of citations: 7.

[C7] T. Magesacher, P. Ödling, and P.O. Börjesson, "On time-domain guard-interval nulling for PSD-constrained channels," in *Proc. 12th Intl. OFDM-Workshop InOWo'07*, Hamburg, Germany, Aug. 2007, pp. 128–131.

[C8] J. Rius i Riu, J. Rosenberg, F. Lindqvist, M. Tilocca, C. Bianco, B. van den Heuvel, P. Ödling, T. Magesacher, M. Berg, J. Sorio, A. Uvliden, and P.O. Börjesson, "The IST-MUSE approach to DSL loop qualification and monitoring," in *Proc. 3rd Broadband Europe Conference*, Geneva, Switzerland, Dec. 2006, Number of citations: 3.

[C9] T. Magesacher, J. Rius i Riu, P. Ödling, P.O. Börjesson, M. Tilocca, and M. Valentini, "Limits of ultra-wideband communication over copper," in *Proc. Intl. Conference on Communication Technology (ICCT) 2006*, Guilin, China, Nov. 2006, Number of citations: 2.

[C10] T. Magesacher, J. Rius i Riu, M. Jakovljević, M. Loiola, P. Ödling, and P.O. Börjesson, "Measurement and modeling of short copper cables for ultra-wideband communications," in *Proc. SPIE OpticsEast Broadband Access Communication Technologies*, Boston, MA, USA, Oct. 2006, Number of citations: 4.

[C11] T. Magesacher, P. Ödling, and P.O. Börjesson, "A fair comparison of transmitter-based spectral shaping techniques," in *Proc. 11th Intl. OFDM-Workshop InOWo'06*, Hamburg, Germany, Aug. 2006, pp. 323–327, Number of citations: 2.

[C12] T. Magesacher, P. Ödling, and P.O. Börjesson, "Optimal intersymbol transmit windowing for multicarrier modulation," in *Proc. 6th Nordic Signal Processing Symp. NORSIG 2006,* Reykjavik, Iceland, Reykjavik, Iceland, June 2006, Number of citations: 7.

[C13] T. Magesacher, P. Ödling, and P.O. Börjesson, "Optimal intra-symbol spectral compensation for multicarrier modulation," in *Proc. Intl. Zurich Seminar on Broadband Communications IZS 2006*, Zurich, Switzerland, Feb. 2006, pp. 138–141, Number of citations: 7.

[C14] T. Magesacher, P. Ödling, and P.O. Börjesson, "Adaptive interference cancellation using common-mode information in DSL," in *Proc. European Signal Processing Conf. EUSIPCO 2005*, Antalya, Turkey, Sept. 2005, Number of citations: 12.

[C15] P. Ödling, W. Henkel, P.O. Börjesson, G. Tauböck, N. Petersson, and A. Johansson, "The Cyclic Prefix of OFDM/DMT - An Analysis," in *Proceedings of the 2002 International Zurich Seminar on Broadband Communications (IZS 2002)*, 2002, Number of citations: 79.

[C16] T. Magesacher, P. Ödling, P.O. Börjesson, W. Henkel, T. Nordström, R. Zukunft, and S. Haar, "On the capacity of the copper cable channel using the common mode," in *Proc. IEEE Global Telecommun. Conf. GLOBECOM 2002*, Taipei, Taiwan, Nov. 2002, Number of citations: 26.

[C17] F. Sjöberg, R. Nilsson, M. Isaksson, P. Ödling, and P.O. Börjesson, "Asynchronous zipper," in *Proc. IEEE International Conference on Communications*, 1999, vol. 1, pp. 231–235, Number of citations: 34.

[C18] D. Landström, S.K. Wilson, J.-J. Van De Beek, P. Ödling, and P.O. Börjesson, "Symbol time offset estimation in coherent OFDM systems," in *Proc. IEEE International Conference on Communications*, 1999, vol. 1, pp. 500–505, Number of citations: 26.

[C19] R. Nilsson, O. Edfors, M. Sandell, and P.O. Börjesson, "Analysis of two-dimensional pilot-symbol assisted modulation for OFDM," in *Proc. IEEE International Conference on Personal Wireless Communications*, 1997, pp. 71–74, Number of citations: 86.

[C20] O. Edfors, M. Sandell, J.-J. van de Beek, S.K. Wilson, and P.O. Börjesson, "OFDM channel estimation by singular value decomposition," in *Proc. IEEE Vehicular Technology Conference*, 1996, vol. 2, pp. 923–927, Number of citations: 136.

[C21] J.-J. van de Beek, O. Edfors, M. Sandell, S.K. Wilson, and P.O. Börjesson, "On channel estimation in OFDM systems," *IEEE Vehicular Technology Conference*, vol. 2, pp. 815–819, 1995, Number of citations: 1580.

[C22] J.-J. van de Beek, M. Sandell, M. Isaksson, and P.O. Börjesson, "Low-complex frame synchronization in OFDM systems," in *Proc. Annual International Conference on Universal Personal Communications - Record*, 1995, pp. 982–986, Number of citations: 286.

3. Overview articles, book chapters, books

[O1] T. Magesacher, P. Ödling, P.O. Börjesson, S. Höst, E. Areizaga, M. Berg, and E. Jacob, "Paving the road to gbit/s broadband access with copper," chapter in the book *"Convergence of Mobile and Stationary Next-Generation Networks, WILEY, ISBN 978-0-470-54356-6*, 2010.

[O2] T. Magesacher, J. Lee, P. Ödling, and P.O. Börjesson, "Synchronization for OFDMA," chapter in the book *"Orthogonal Frequency Division Multiple Access Fundamentals and Applications", AUERBACH, ISBN 978-1-4200882-4-3*, 2010.

[O3] J.-J. van de Beek, P.O. Börjesson, P. Ödling, and S.K. Wilson, *Orthogonal frequency-division multiplexing (OFDM)*, Invited chapter in "Review of Radio Science 1996-1999. Comm. C: Signals and Systems". International Union of Radio Science (URSI), Oxford University Press, 1999, Number of citations: 27.

4. Patents

[P1] A. Fertner, H. Almeida, M. Berg, P.O. Börjesson, K. Ericson, and F. Lindqvist, "Estimation of a quantity related to impedance," *patent application, US Patent 20,130,158,922*, 2013.

[P2] P.O. Börjesson and F. Lindqvist, "Characteristics determination of a digital subscriber line," *patent application, US Patent 8,130,911*, 2012.

[P3] M. Berg, P.O. Börjesson, and D. Cederholm, "Method and arrangement in a telecommunication system for estimating frequency dependent resistance," *patent application, EP Patent 2,494,701, US Patent 20,120,221,271, WO Patent 2,011,050,863*, 2012.

[P4] F. Lindqvist and P.O. Börjesson, "Method and system to determine one or more properties of a digital subscriber line using an adaptive finite impulse response filter," *patent application, EP Patent 1,829,347*, 2012.

[P5] F. Lindqvist, P.O. Böresson, and A. Fertner, "Transmission line parameter determination," *patent application, WO Patent 2,012,138,271*, 2012.

[P6] A. Fertner, P.O. Börjesson, K. Ericson, F. Lindqvist, I. Pappa, S. Höst, and M. Berg, "An arrangement and method relating to analysis of transmission lines," *patent application, EP Patent 2,504,931, US Patent 20,120,215,503, WO Patent 2,011,053,212*, 2012.

[P7] A. Fertner, P.O. Börjesson, and K. Ericson, "Method for transmission line analysis," *patent application, EP Patent 2,272,177*, 2011.

[P8] M. Berg, S. Höst, F. Lindqvist, K. Ericson, P.O. Börjesson, I. Pappa, and A. Fertner, "A low-order causal twisted-pair cable model with Hilbert transform implemented as closed-form expression," *patent application, PCT/SE2010/050015*, filed with the Swedish Patent Office 8/1, 2010.

[P9] M. Berg, D. Cederholm, and P.O. Börjesson, "Insertion loss estimation from single frequency data," *patent application, PCT/EP2009/067733*, filed with the Swedish Patent Office 22/12, 2009.

[P10] M. Berg, D. Cederholm, K. Ericson, and P.O. Börjesson, "Method for Transmission Line Analysis," *patent application, PCT/SE2009/051349, WO/2010/064977, EP Patent 2,359,488*, filed with the Swedish Patent Office 27/11, 2009, pub. date 2010-06-10.

[P11] A. Fertner, K Ericson, M. Berg, D. Cederholm, and P.O. Börjesson, "Passive SELT," *patent application, PCT/SE2009/051165, WO/2010/140945, EP Patent 2,438,686*, filed with the Swedish Patent Office 13/10, 2009, pub. date 2010-12-09.

[P12] A. Fertner, K Ericson, M. Berg, D. Cederholm, and P.O. Börjesson, "A Method for Estimating Transmission Properties of a Telecommunications Transmission Line," *patent application, PCT/SE2009/051016, WO/2011/031199, EP Patent 2,476,211*, filed with the Swedish Patent Office 11/09, 2009, pub. date 2011-03-17.

[P13] A. Fertner, K. Ericson, and P.O. Börjesson, "Improved Single-Ended Line Testing (SELT) Algorithm for determining Primary Parameters of the Transmission Line," *patent application, EP 08779266.9*, filed 2008-04-23, pub. date 2011-01-12.

[P14] F. Lindqvist, P. O. Börjesson and A. Fertner, "A method and a system for cable or subscriber loop investigation performing loop topology identification," *patent application, EP 06704611.0*, filed 2006-01-31.

[P15] A. Fertner, F. Lindqvist and P. O. Börjesson, "Load coil detection and localization," *patent application, EP 06831780.9*, filed 2006-12-20, pub. date 2008-09-03, Number of citations: 1.

[P16] S. Allevad, P. Ödling, A. Fertner, H. Back, F. Lindqvist, P.O. Börjesson and J. Rius i Riu, "Method, device and program product for estimating properties of a telecommunication transmission line," *patent application, EP 05798831.3*, filed 2005-10-27, pub. date 2008-07-09.

[P17] F. Lindqvist and P. O. Börjesson, "Characteristics determination of a digital subscriber line," *patent application, EP 04801288.4*, filed 2004-12-01.

[P18] J. G. Rosenberg, F. Lindqvist, A. Wiå, A. Fertner, A. F. Jensen, P. O. Börjesson and P. Ödling, "Method and arrangement for signal loop test," *patent application, EP 04717331.5*, filed 2004-03-04, pub. date, 2006-02-15, patent no 1625735, patent date 2008-01-16, Number of citations: 2.

[P19] G. Bahlenberg, D. Bengtsson, A. Isaksson, M. Isaksson, J. Johansson, M. Johansson, K. Ljunggren, H. Öhman, S.G. Ökvist, S.-R. Olovsson, L. Olsson, T. Stefansson, P.O. Börjesson, N. Grip, P. Ödling, R. Nilsson, F. Sjöberg, S.K. Wilson,, "Improvements in, or Relating to, Subscriber Line Transmission Systems," *patent application, PCT/SE98/02030*, filed with the Swedish Patent Office 11/11, 1998, pub. date 2004-05-18, WO Patent WO/1999/026,365, date 27 May 1999, EP Patent 1,031,199, date 26 Feb 2003, US Patent 6,738,440, 18 May 2005, Number of citations: 3.

6. Popular science contributions

[U1] T. Magesacher, P. Ödling, and P.O. Börjesson, "Capacity of the Swedish copper access network," in *Proc. Radio Vetenskap RVK 2005*, Linköping, Sweden, June 2005.

CV

Name: Thomas Magesacher	**Doctorial degree:** 2006-09-28
Birthdate: 19740507	**Academic title:** Docent
Gender: Male	**Employer:** Lunds universitet

Research education

Dissertation title (swe)

Dissertation title (en)

Common-Mode Aided Wireline Communications

Organisation	Unit	Supervisor
Lunds universitet, Sweden Sweden - Higher education Institutes	Elektro- och informationsteknik 107201	Per Ödling

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20205. Signalbehandling	91-7167-041-6	2006-09-28

CV

Name: Per Ola Börjesson	**Doctorial degree:** 1980-05-27
Birthdate: 19450908	**Academic title:** Professor
Gender: Male	**Employer:** Lunds universitet

Research education

Dissertation title (swe)

Data kompression och signalskattning med tillämpning på digitalt EKG

Dissertation title (en)

Data compression and signal estimation with application to digitized electrocardiograms

Organisation	Unit	Supervisor
Lunds universitet, Sweden Sweden - Higher education Institutes	Lunds Tekniska Högskola - Teletransmissionsteori	Göran Einarsson

Subject doctors degree	ISSN/ISBN-number	Date doctoral exam
20205. Signalbehandling	LUTEDX/(TETT-1002)/1-12/(1980)	1980-05-27

Publications

Name: Thomas Magesacher	**Doctorial degree:** 2006-09-28
Birthdate: 19740507	**Academic title:** Docent
Gender: Male	**Employer:** Lunds universitet

Magesacher, Thomas has not added any publications to the application.

Publications

Name: Per Ola Börjesson	**Doctorial degree:** 1980-05-27
Birthdate: 19450908	**Academic title:** Professor
Gender: Male	**Employer:** Lunds universitet

Börjesson, Per Ola has not added any publications to the application.

Register

Terms and conditions

The application must be signed by the applicant as well as the authorised representative of the administrating organisation. The representative is normally the department head of the institution where the research is to be conducted, but may in some instances be e.g. the vice-chancellor. This is specified in the call for proposals.

The signature*from the applicant*confirms that:

- the information in the application is correct and according to the instructions form the Swedish Research Council
- any additional professional activities or commercial ties have been reported to the administrating organisation, and that no conflicts have arisen that would conflict with good research practice
- that the necessary permits and approvals are in place at the start of the project e.g. regarding ethical review.

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- the institution approves the cost-estimate in the application
- the research is conducted according to Swedish legislation.

The above-mentioned points must have been discussed between the parties before the representative of the administrating organisation approves and signs the application.

Project out lines are not signed by the administrating organisation. The administrating organisation only sign the application if the project outline is accepted for step two.

Applications with an organisation as applicant is automatically signed when the application is registered.