# Exjobb [3 positions] – High Performance Wireless Control for Critical Industrial Applications

ABB is a global leader in power and automation technologies that enable utility and industry customers to improve their performance while lowering environmental impact. ABB is present in more than 100 countries and employs about 135,000 people. ABB Corporate Research, in close collaboration with varied ABB business areas, is developing the foundations for the next generation of ABB products. In Sweden, ABB Corporate Research, located in Västerås, employs 280 scientists from over 40 countries with expertise in automation and power technologies for manufacturing, consumer and process industries as well as power utilities.

## Background

Wireless communication is expected to take a key role in next generation control systems in the era of Industrial 4.0. In many critical applications such as factory automation, industrial robotics, remote surgery, mining automation, power systems, and high-voltage power electronics control, wireless can largely reduce the costs currently brought by wired solutions (e.g. fiber optic) for material, installation, and maintenance over very long life-cycles (e.g. 30 years). Moreover it can enable new use cases by flexible and even mobile deployment (e.g. mobile robots). However, these scenarios required the simultaneous fulfillment of critical requirements, such as Gigabit/s (Gbps) level data rate, sub micro second (sub-µs) level latency, and packet error rate (PER) lower than $10^{-6}$. These requirements, so-called WirelessHP, have been shown to be hundreds of times beyond the state-of-the-art[1]. Moreover, a preliminary proposal for low-latency physical (PHY) layer design has been developed and implemented on a narrowband software-defined radio (SDR) platform[2]. However, several features need to be added to the current design in order to meet the challenging requirements of WirelessHP.

## Task

In this project, you will investigate different features for PHY layer of industrial wireless networks, e.g. millimeter-wave (mmWave) and multiple-input multiple-output (MIMO). The performance figures will be first assessed by theoretical analysis and simulation and then verified through implementation on high performance SDR platform and experiments in real industrial environments, e.g. factories, mines, and/or power stations. Realistic channel models and interferences models relevant to these scenarios will also be established and validated by experiments.

<u>Position 1:</u> mmWave for industrial wireless control
**Tasks:** Review the latest progress of low-latency wireless communications in the mmWave spectrum (28 GHz, 60 GHz and beyond), including beamforming strategies, propagation models and high-bandwidth processing. Design a low-latency mmWave PHY layer and implement it on

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[1] M. Luvisotto, Z. Pang and D. Dzung, "Ultra High Performance Wireless Control for Critical Applications: Challenges and Directions," in IEEE Transactions on Industrial Informatics, vol. 13, no. 3, pp. 1448-1459, June 2017.

[2] M. Luvisotto, Z. Pang, D. Dzung, M. Zhan and X. Jiang, "Physical Layer Design of High Performance Wireless Transmission for Critical Control Applications," in IEEE Transactions on Industrial Informatics, DOI:10.1109/TII.2017.2703116

a high-performance SDR platform equipped with an upconverter that can move the signal to the selected frequency band. Test its performance in terms of latency and reliability.

**Required Skills:** Information and communication theory, PHY layer of wireless networks, Matlab, mathematics, FPGA programming

Position 2: MIMO for industrial wireless control

**Tasks:** Review the latest progress in wireless MIMO communications to achieve spatial multiplexing (i.e. increased data rate) and/or spatial diversity (increased reliability), specifically evaluating the impact of these configurations on latency. Design a low-latency MIMO PHY layer and implement it on a high-performance SDR platform equipped with multiple RF interfaces (up to 4x4). Test its performance in terms of latency and reliability.

**Required Skills:** Information and communication theory, PHY layer of wireless networks, Matlab, mathematics, FPGA programming

Position 3: Model-based SDR technologies for industrial wireless control

**Tasks:** Review the latest progress of model-based SDR hardware platforms, tools, and implementations for wireless networks prototyping. Compare the performance of different frameworks (e.g. Mathworks Simulink, Xilinx Vivado, NI Labview) through literature review and real-world experiments. Focus specifically on the usage of such tools for the realization of wireless demonstrators characterized by low-latency and high data rate.

**Required Skills:** Information and communication theory, PHY/MAC layer of wireless networks, SDR, Matlab, mathematics, FPGA programming

**Shared requirements**

Despite the diverse requirements of different tasks, all these positions are seeking candidates with both deep theoretical knowledge and strong practical skills (coding, debugging, and testing), ambitions of making breakthrough, excellent scientific writing, good English presentation, and team working. The preferred internship candidate is a PhD student in the communications field. However, other profiles will be also evaluated, including master students looking for an MSc thesis. At the end of the internship, the candidate will be expected to produce high quality slides, paper manuscript(s) aiming for IEEE journals, and workable demonstrator(s).

**Career opportunity**

If you can eventually deliver all the results with expected quality, as most of our students have done in recent years, you will be superiorly competitive for both academic positions and job hunting. There are also opportunities in ABB and our collaborators.

**How to apply**

You must send **ALL** of the following docs: cover letter, CV, bachelor transcripts, master transcripts, and bachelor/master thesis (if present). Incomplete applications will not be reviewed. More evidence of your competence is not mandatory by strongly desirable including publications, patents (only non-confidential information), reports, essays, pictures or videos of demos, recommendation letters, etc. You **MUST** send an email to the supervisor with a subject in format of **"[Internship] <your name>-<university name>-<position name>**". Emails with a wrong subject will be not be considered.

NOTE: ABB can provide free accommodation in some "ABB apartment" in Vasteras during the period of internship.

**Supervisor/Contact**

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