ABB Research Grant Program

2012 Call for Proposals

1 OVERVIEW

ABB already collaborates with a number of academic research groups world-wide. The ABB Research Grant Program is intended to enlarge and complement the circle of our university partners.

1.1 Research grants

We plan to award research grants for the 2013 calendar year, typically in the range of $50,000 to $80,000, for research in the power and automation area. While we expect to fund projects over multiple years to support graduate students, we will approve funding decisions for one year at a time. Applications should combine academic research with industrial application.

The applications must be submitted by a main applicant who is a professor associated with a university, university college, or research institute. The main applicant will be ABB's sole point of contact.

Applicants are invited to submit proposals according to the requirements outlined in Section 3. ABB will review the proposals and select which proposals will be awarded a grant. All applicants will be informed about the outcome of the review.

1.2 Evaluation process

Applications will be assessed by an ABB-internal evaluation committee. The applications will be evaluated with respect to how well they correspond to the topics described in section 2 and with respect to the expected outcome of the project. In addition, the following aspects will be taken into account:

- Objective, choice of problems and working methods on the basis of novelty and match with the topics in this call.

- Scientific quality of the project and track record of the applicant(s)

- Balance between content and requested amount of funding

- Prior track record in collaborative work, especially with industry

1.3 Terms and conditions

The ABB evaluation committee will determine the successful grant recipients. ABB expressly reserves the right not to grant any award if no submission is deemed sufficient and suitable.

Each applicant shall bear its own costs prior to the announcement of the grant recipients.

Granting of the award shall be conditional upon the proposed grant recipient's signing of the "ABB Research and Development Agreement with Universities"

(http://www02.abb.com/global/abbzh/abbzh254.nsf/0/94300f655fd20174c12578cc003125ac/$file/ABB_Research_and_Development_Agreement_with_Universities.pdf)

before the start of the research project. All disputes arising out of or in connection with the ABB Research Grant Program shall be governed in accordance with Swiss law under exclusion of its conflict of laws rules and the United Nations Convention on International Sale of Goods. Place of jurisdiction shall be Baden, Switzerland.

Upon submitting an application to ABB, each applicant acknowledges and agrees to be bound by the above-mentioned terms and conditions.

1.4   Proprietary and Confidential Information

ABB will treat all information submitted in proposals as non-confidential and non-proprietary. Applicants must ensure that no confidential or proprietary information is included in submitted proposals.

1.5   Important dates

2012-10-01

Announcement of program on ABB website

2012-11-01

System opens to accept applications

2012-11-30

Deadline for submitting application.

2012-12-31

Start communication award decisions.

2013-01-01 to 2013-12-31

Funding period

All dates are subject to change by ABB.

2 RESEARCH TOPICS

ABB, a world leading company in automation and power, is calling for unique and innovative research proposals. The topics for the 2012 call are listed below.

AUTOMATION SYSTEMS

Topic 1: Distributed platform for the integration of system of systems

The availability of low-cost devices provided with non-negligible processing power and increased reliability is changing deeply everyone's life. For example, more and more control and monitoring functions can be currently realized by means of computer-based systems. Moreover, in the past decade intensive studies have been carried out about high-performance communication systems, which concern real-time data exchanges, quality-of-service, validation techniques for distributed applications, and so on. As a consequence, the deployment of applications is nowadays moving from centralized solutions to distributed architectures, where processing (and working, as well) is spread across many intelligent devices. Automation systems (process, factory and building) will become more distributed in future with the overall functionality being divided and distributed on different levels (devices, subsystems, systems, cloud). However, these devices and subsystems still need to be integrated leaving the following key questions open:

- Scalable architecture for a distributed platform for the integration of System of Systems
- Middleware for the aggregation of distributed integration entities
- Technologies for the implementation of integration entities scalable from devices (multiple HW/OS platforms) to subsystems and systems
- Workflow for the management of such a distributed integration platform including engineering, commissioning, operation, monitoring etc.
- Technologies for a "self-organizing" distributed integration platform
- How to describe the distributed function (logic)
- How to describe and negotiate the requirements for the distributed function
- Local cloud (distribution among controllers and devices) and global cloud (data centers)
- Communication services for distributed platform
- How to ensure the right quality of service (performance, availability, security)

Topic 2: Reliable industrial embedded systems

Computing power of devices increase which leads to the trend that (process, building, distribution, factory) automation systems will become more distributed in future with the overall functionality being divided and distributed on different levels (devices, subsystems, systems, cloud). This increase in the number of connected devices will lead to substantial challenges in terms of device maintenance. How can the life cycle of these

distributed devices be managed and how can advances in material science be taken into account in order to minimize overall energy consumption and maximize reliability?

Research Topics

- Lifecycle management and embedded systems (methodology, platforms and tools)
- Reliable electronic components

Topic 3: Network simulation

The design of Ethernet networks for automation systems is today mostly done based on practical experience. Network simulation could be used to verify the network design by predicting the behavior of the network (latency, jitter, bandwidth usage, traffic separation (VLANs, multicast filtering), prioritization, time synchronization, reaction to topology changes....), without an actual network being present. The simulator can be purely software or a combination of hardware and software. The software is using mathematical formulas to emulate the behavior of network devices (switches, routers, end-devices).

Research topics:

- Simulation framework
- Simulation models (devices, protocols)
- Co-simulation with real devices
- Simulation with captured data

Topic 4: Automation engineering concepts, methods and technologies

This topic requests for proposals to increase the engineering efficiency by new concepts and methods related to improve the engineering collaboration, tool and data integration, re-use, automated testing; utilizing innovative technologies like cloud based approaches, simulation, virtual plants, mobile and keyboardless platforms and supporting workflow support, and -generation and measurement of efficiency.

ELECTRICAL MACHINES AND CONVERTERS

Topic 5: Research in electrical machines

This topic requests for proposals related to energy efficiency, railway traction, electrical or hybrid vehicle power drive train, renewable power generation, industrial systems, special applications, fault tolerance, synchronous machines, induction machines, special machine topologies, integral designs, linear machines, machine cooling, loss minimization, multi-physics optimization.

Topic 6: Power electronic converters

This topic requests for proposals related to low and medium voltage converter topologies for industrial drives, wind and solar energy applications, electromagnetic compatibility of converters, low and medium voltage dc/dc converters, magnetic components for converters, high power density converters, converters employing WBG semiconductors,

harmonic and high frequency filters in converters, control of motor drives and grid inverters, uninterruptible power supplies, low voltage dc systems in buildings and island applications, power electronics for deep sea applications, power electronics for harsh environments.

GRIDS

Topic 7: Security for smart grid (heterogeneous communications and embedded devices)

The way that electricity flows in today's power grid is mainly from the big energy plants in a high voltage transmission system to the areas of usage where it is transformed to medium voltage level and distributed out to the different consumption locations where it is typically transformed to low voltage power used by consumers or in some cases used directly in large industrial plants. In the smart grid systems the energy will flow in a much more complex way. This dramatically changes the control system to be much more complex and needing much more computation and communication. The communication network that is needed to support control for the complex electrical grid is a complicated system with a large number of different physical networks and protocols. The heterogeneous nature of this network is a challenge to define and maintain and not the least to keep secure. Cyber security is a moving target: new threats and vulnerabilities require that cyber security is re-evaluated and that security infrastructure consequently should be able to adapt/meet new requirements. Effective solutions require collaborations and strong partnerships (nobody can do it alone). We are therefore interested in collaborating with external entities to improve cyber security solutions.

Research topics:

- Security of communications protocols
- How to select HW security mechanisms that meet performance requirements
- Improving performance of security protocols by studying impact of different cipher suites on performance
- Improving methods for threat and risk assessment

Topic 8: Distribution grid management

Utility distribution grids are undergoing transformative changes both on the primary level of the grid (sources (e.g. distributed solar panels), hardware (e.g. small energy storage) and loads (e.g. active demand)) as well as on the secondary side (automation hardware, (e.g. smart meters), advanced control algorithms (e.g. voltage control)). ABB conducts research in the field of active distribution grids, where we focus on leveraging an increasing penetration of information and communication technologies as well as controllable primary hardware to improve the grid's reliability, energy efficiency and flexibility. ABB welcomes proposals that address one or a collection of the following challenges:

- How can data from e.g. smart meters be used to improve the management of the distribution grid?

- How can distributed energy resources be fully integrated from a technical, economic and policy perspective?

- How can distributed energy resources (including active demand) contribute to overall power system control?

- What functionality (e.g. voltage control) and where is it needed (e.g. control center or in the field) to operate evolving distribution grids?

- Should, and if so how, existing load modeling approaches change when we consider active distribution grids?

Topic 9: Transmission grid management

Originally transmission systems have been over engineered to have ample spare operating margins. As the load grew and fewer grid-strengthening investments were made, a faction of the community started promoting that these systems should be operated closer to their physical --- rather than their perceived --- limits. Many practitioners have viewed this as an academic statement, because 1) they believed that the existing systems, due to remaining margins, would not face such challenges in the foreseeable future, and 2) the expected challenges in changing the operation paradigm. Evidence is now emerging that due to a combination of under investment in these systems, regulatory challenges with building new lines (e.g. NIMBY effect), change of load behavior (more active demand) and new generation sources (variable-output renewables) that there are points in time when a transmission grid is in fact very near to its limit and an increasing number of post-fault corrective actions are required to preserve system stability.

ABB conducts research into improving the technologies for operating these Transmission Systems, and ABB welcomes proposals that address one or a collection of the following challenges:

- Improved situational awareness and next generation control room human machine interface (HMI) technology

- Scalable optimization techniques for market-based resource scheduling under high levels of uncertainty

- High performance computing for power system simulation, monitoring and control. Could such advances change the existing operating paradigm?

- How do you incorporate and use new controllable grid hardware/systems (e.g. HVDC, FACTS, DERs) as well as increasingly available/new data sources (e.g. PMUs, line temperature measurements) for system-wide power grid protection and control for economic operation and system integrity enhancement

- Are the existing load modeling approaches adequate when one considers changes at the distribution level? How should these approaches be modified?

Topic 10: Grid asset monitoring and diagnostics

With an increase of available real time and near-real time data in modern power systems (at transmission, distribution and load level) there is a drive to explore what information could be extracted from the set of heterogeneous data to benefit power system operation and maintenance. Beyond the operational applications mentioned above, other areas where data analytics can lead to breakthroughs are for asset management and smart grid equipment. With limited maintenance budgets and aging equipment, utilities need to manage their maintenance budget more effectively by transitioning from time-based preventive maintenance to condition-based maintenance. ABB welcomes proposals that address one or a collection of the following challenges:

- What architectures and data are required to realize an asset management system for a T&D utility?

- What methods are suited for utility-data analytics?

- What condition-based operating strategy using real time and historical sensor data can be used to extend the operating life of grid assets while preserving their intended functions in the larger system at or exceeding rated capacity?

- How would a piece of power apparatus change, while meeting or exceeding grid-imposed requirements, if data-analytics driven intelligence is added?

Topic 11: New fault current limiting technologies for power transmission and distribution

Grids interconnection and renewables integration in existing grids may often require main changes in protection performance of power transmission and distribution grids. One of the most challenging aspect is the potential increase of fault currents in grids originally dimensioned for a different protection level. We seek for system and apparatus studies aiming to propose new fault current limiting technologies for the transmission and distribution range, where reliability, availability and cost-efficiency are parameters to be taken into account among the others.

HIGH VOLTAGE DC TRANSMISSION

ABB pioneered HVDC for more than 50 years ago and is now the leading manufacturer in the world for both classic HVDC using line-commutated converters and HVDC Light®, which utilizing voltage source converters. The big trends within the HVDC area are to increase transmitted power, reduce cost and losses and expand the transmission from point-to-point connections to a multi-terminal HVDC grid.

Topic 12: Future converter technologies

Traditionally, the switching frequency has been reduced in order to reduce the losses. However, with semiconductors using high band width gaps (such as SiC), the switching frequency can increase without penalty on losses. Therefore, a new field of converter topology solutions opens up. How to do an investigation on converter topology solutions with the positive and negative aspects on each topology together with current/voltage/power control and semiconductor switching strategies?

The dominant topology family is the voltage source converter. However, with new semiconductors utilizing reversed blocking capability together with low losses open up a new area of current source converters and a mix between voltage and current source converter. How can we take the next step in converter technology to reduce losses, cost and increase voltage and current capability for GW converter stations?

Topic 13: Visionary HVAC and HVDC utilizing super-conducting transmission lines

In order to reduce the losses for AC and DC transmissions, the voltage level has been increased to reduce the current and, thus, reduce the conduction losses in the transmission lines. Assume now that a breakthrough will happen in superconducting research that results in cost effective super-conducting cables for AC and DC transmission. Thus, the losses will be almost zero for DC transmissions and be very low for AC transmissions.

What implication will loss-less AC transmission lines have on new devices in order to control the system? What will the new practical voltage levels be? Do we need active oscillation dampers, power flow controllers and so on? How should we design and control the new devices?

What implication will super-conducting transmission lines have on a DC system:

- System design?
- Voltage levels?
- Converter design (topology, valves, semiconductors, …)?
- Control of converters for a point to point system?
- Control of converters for a multi-terminal DC system?

Topic 14: Converter with extra high reliability and availability together with ultra-low maintenance requirements

How should a future high power MV or HV converter that will be used for grid applications (DC/DC, DC/AC, AC/DC conversions) be designed in order to handle extra high reliability and availability together with ultra-low maintenance requirements? Of course, both losses and cost should be kept low.

How to determine the reliability and availability figures?

Topic 15: Embedded HVDC line in AC grid

Assume an AC grid in which a new transmission line is built or an AC line is converted into a DC line, i.e., a point to point HVDC line with a converter station in each end. Moreover, assume that the power capability of the new DC point-to-point HVDC connection has a non-negligible power rating in comparison to the surrounding AC grid.

What features can the new system add in form of flexibility, increased power handling, stability, … Moreover, how should the controllers in the two HVDC converter stations be designed to fulfill the new functionalities?

Topic 16: Long distance bulk power HVDC transmission technologies

Electricity is mainly transmitted from power stations to consumers via an electricity transmission grid. With advances of establishing non-dispatchable and/or remote non-fossil fueled energy generation the formation of super grids becomes an important technology enabler. Wide area super grids plans typically call for bulk transmission using high voltage direct current (HVDC) lines.

We seek innovative HVDC transmission concepts and novel solutions in the area of high capacity transmission technologies that are suitable for "undergrounding" (land and sea).

Specific research questions include, but are not limited to, the following:

- Novel technologies suitable for transmission capacity > 5GW
- Cost efficient, long transmission distance technologies
- Excellent system reliability
- Minimized "right of ways"
- Optimized power losses
- Simple installation technologies

INTELLIGENT MATERIALS AND PROCESSES

Topic 17: Self-healing solid dielectrics

In the last decade self-repairing solid materials have been successfully developed, engineered and partially market introduced for structural applications. However, significant achievements for self-healing polymers and polymer composites for dielectric applications (damaged by electrical discharge activities) are still missing. ABB is working on creating novel dielectric materials for the next generation of high voltage power products. We seek for proposed material concepts, solutions for the design and synthesis/formulation of novel materials that show the capabilities (inherent or integrated) of self-repairing dielectric properties.

Topic 18: Low or high permittivity dielectrics

Polymeric materials are extensively used as electrical insulation for a wide range of power products. Continued progress in rising the operating voltage level calls for longer insulation distances, consequently leading to larger product dimensions. Low and high permittivity materials can be utilized to control the electric field distribution and unify the maximum electric stresses in the used insulation materials. Consequently, tailored and controllable permittivity materials are an important enabler for the future generation of ABB's compact power products.

We seek for novel routes to develop dielectric materials with a controllable permittivity characteristics having the following features: 1) low (<2) or high (>10) dielectric constant, 2) low loss and high electrical breakdown strength; 3) excellent mechanical, thermal and long term properties.

Topic 19: Novel process technologies for insulation systems

The economic manufacturing of defect free, large volume insulation components is a main challenge, where new process technologies, new materials and/or new design concepts can lead to major advances. Along these lines we are seeking for i) novel processes technologies for realizing functionally graded materials (materials characterized by a compositional gradient) that can be designed for specific function and applications, ii) new types of insulation materials with unique processing and performance properties (e.g. thermoplastic processing capability combined with thermoset-type performance profiles) and iii) new material processing concepts with morphological control down to the nanometric scale.

Topic 20: High thermal conductivity insulation

Polymers are good electrically insulating materials but present generally low thermal conductivity (typically 0.2-0.3 W/m.K). This is a major drawback in various applications, where the heat generated through the conductor needs to be dissipated.

One possibility to overcome this is to fill the insulation with heat conductive fillers, However, the insulation material becomes very viscous due to the high filler content and is difficult to process.

We seek for innovative polymers having an inherently high thermal conductivity (> 1 W/m.K) and easy processable (low processing viscosity).

Topic 21: Create ideal capacitor based on superinsulator and superconductor materials

Would it be possible to build in ideal capacitor with no leakage current and almost no energy lost as heat using a combination of superinsulator and superconductor materials? Superinsulator property in TiN at low temperature has been demonstrated in 2008 by Russina Valerii Vinokur and Tatyana Baturina.

MOTION SYSTEMS

Topic 22: Mechanisms & manipulators

ABB has a large number of different types of motion systems in our product portfolio, ranging from circuit breaker drives to robot manipulators. The trends for the systems are towards:

- Decreasing cost
- Lower weight & smaller footprint
- Higher speed
- Higher energy efficiency

To meet the challenges introduced by the above trends we are calling for unique and innovative research proposals on topics related but not limited to:

- Actuation principles.
- Gearbox concepts.

- New structural materials & manufacturing methods.

- Lightweight designs.

- Mechanical energy storage solutions, allowing driving highly dynamic movements.

Topic 23: Model-driven motion control engineering

The design of a complete motion control solution requires definition of several aspects like the motion control topology (e.g. centralized, decentralized) and control parameters. In order to support our customers in setting up a motion control solution, we seek for methods to extract relevant information out of existing CAD-data. These data can contain valuable information like mass and inertia of moved parts as well as kinematic constraints and coupling between axes. With this information, the complete motion control design including an optimal control topology, dimensioning components, building a BOM and generating initial controller parameters should be retrieved by suitable algorithms.

Topic 24: Ease of use for industrial robots

Industrial robots need to perform tasks in a very robust way. These tasks range in complexity from simple pick and place tasks to applications that have many process variables, such as welding, painting, assembly and sealing. One of the major challenges in utilizing a robot is enabling a process expert to teach the robot its task without also having to become a robot expert or learning a robot programming language. ABB is seeking new programming paradigms, especially those that allow users to interact with the robot in a more natural, human-to-human manner. We are also seeking new approaches for human-robot collaboration, where the human and robot understand each other better and the human is both safe and has a safe feeling. New programming paradigms could also include new interface devices beyond the traditional industrial robot teach pendants.

Topic 25: Low cost robotic gripper capable of in-hand manipulation

Robotic assembly of small non-flat parts is traditionally done today using an industrial robot and a simple 1-DOF gripper, typically a servo or pneumatic finger mechanism. This setup is the same as a human using a pair of pliers. For robots to truly rival human dexterity during small part assembly, more advanced object manipulation is required. ABB is searching for proposals to design and build a gripper that is capable of firmly grasping a wide range of varying components and also is capable of reorienting and positioning the object locally within the gripper to orient it for assembly. Simple intuitive programming is a key requirement. The system should be able to feedback the orientation and position of the object to enable the robot to correctly position it for assembly.

PROCESS CONTROL AND PRODUCTION MANAGEMENT

Topic 26: Integration of production control and scheduling

The traditional boundaries between tracking setpoints and economic optimization (e.g., through scheduling, planning) are rapidly vanishing. This calls for new modeling paradigms and methods to optimally and efficiently combine the different modeling scales and dynamics. The target is to develop industrially applicable collaborative "next generation" solutions to enable true synergies from the control level all the way to ERP.

SENSORS

Topic 27: Current Sensors for low-voltage DC and low variable frequency

Existing current-sensor technologies working in DC and at low frequency (shunts, hall sensors) have performances (linearity, dynamic range, sensitivity) inadequate for application in protection devices (circuit breakers, residual current devices, arc-fault devices, etc.), unless complex and expensive technical solutions (e.g. multisensors arrays or low-noise analog electronics) are used. The lack of such current-sensors prevents the use of electronic trip-units in DC protection devices, apart from a few niche applications, and the use of advanced protection schemes (zone selectivity, current-voltage protection schemes) in applications like PV, DC distribution in buildings and ships, etc. We seek a low-cost DC (or low variable frequency) current-sensor with performance and dimensions suitable for application in LVDC protection devices.

Topic 28: In situ multi-parameter sensors for water.

Turbidity, pH, conductivity, specific ion content, dissolved oxygen, dissolved organics, suspended solids, refractive index are only few parameters among many that are measured today to monitor industrial waste water or potable water in different applications. For this scope, presently, a series of individual sensors are employed requiring high installation and instrumentation costs. Moreover, several of these sensors need consumables in order to function, increasing herewith the cost of ownership and making their use in remote locations difficult or even impossible. We are interested in new and robust in-situ sensing technologies that allow to measure simultaneously more water parameters of interest and which do not need reagents for their functioning. Of particular interest are optical multi-parameter sensing technologies.

Topic 29: Signal processing for operator emulation

Despite a high level of automation in individual systems and devices, most plants and industrial installations are still ultimately operated by people. The main reason for this is that humans remain far better at reacting to unexpected situations and taking informed decisions based on numerous inputs than machines. Nevertheless, it would be interesting to investigate general methods for replacing (or complementing) human operators with machines. The gains would be: substantial increase in reproducibility (i.e., no operator fatigue, no discrepancy between different operators), better portability (i.e., the same "virtual operator" could operate all plants), and possibly lower cost. The technical challenges are in sensing and - mainly - in signal processing. In particular, powerful artificial intelligence methods, new learning procedures (to transfer the knowledge from the operator(s) to the machine) and advanced human-machine interfaces are needed.

SERVICE

Topic 30: Design for service and serviceability

Service and maintenance expenditures remain significant contributors to the total cost of ownership for mechatronic systems, particularly when unexpected failures lead to production line downtime. Therefore, it is critical from the beginning of the design phase to incorporate features which enable condition monitoring and preventive maintenance capabilities. ABB is searching for innovative proposals in the areas of lean monitoring techniques for robust self-monitoring, model based inspection and monitoring, and 'design for reliability' methodologies. Further, methods for quantifying and predicting serviceability of a product based on a virtual model are of great interest.

Topic 31: Equipment lifetime prediction

Searching for methodologies of predicting equipment failure and equipment lifetime, as applicable to actual factory equipment or components, based on measurable quantities. The methodology should be based on as few assumptions as possible and suitable to be automated. Particular attention should be paid to the accuracy as well as to the ease of configuration.

SUSTAINABLE ENERGY

Topic 32: Solar fuels

A long term vision for the transport sector is to close the carbon cycle and generate a liquid renewable hydrocarbon fuel from solar electricity, water, and carbon dioxide captured from the air. Such solar fuel could use the existing fuel infrastructure and power the existing fleet of road vehicles, ships, and airplanes. While many sub-processes of the solar fuel cycle are mature there exist only limited research experience with the efficient capture of carbon dioxide from air

We seek novel technologies and solutions in the area of "sustainable fuels" including, but not limited to:

- Novel processes for efficient capturing of CO_2 from air
- Novel processes for efficient capturing of CO_2 from seawater
- Solid carbon dioxide sequestration through industrially enhanced carbonation of abundant silica minerals

OTHER RELATED RESEARCH

Topic 33: Other related topics

We solicit research proposals on any other research topics related to Power and Automation technologies.

3   GUIDE TO SUBMITTING PROPOSALS

The applications should be sent to ResearchGrantProgram@se.abb.com

The application is limited to eight pages (A4, 12pt, PDF) and must include the following sections:

- Project title and requested amount of funding
- Relevant Topic Number(s) on RFP
- Abstract
- Context and motivation
- Aims and objectives
- Related Work
- Proposed method
- How will success/progress be measured?
- Execution plan
- Resources
- Time plan
- What is the impact if successful?
- Attachments: CVs of applicants (not part of 8 pages)
- Attachments: Bibliography of Related Work (not part of 8 pages)