ECE Graduate Research Seminars-Summer 2024

In Person Sessions: June 3-4, 2024

Remote Sessions: June 17-18, 2024

June 18, 2024-Morning Session

Name: Cristian Arpino
Area of Research: Power Systems Engineering
Name of Supervisors: Rajiv Varma

Laboratory Validation of Battery Energy Storage System as STATCOM (BESS-STATCOM) for Critical Induction Motor Stabilization

Stalling of critical induction motors in process control industries can bring significant financial losses to industrial facilities. STATCOMs and SVCs are typically used for stabilizing such motors. With the tremendous growth of Battery Energy Storage Systems (BESS) it is quite likely that BESS will be installed in distribution networks where such critical motors are connected. This presentation presents the laboratory implementation of a new cost-effective control of a BESS as STATCOM, termed BESS-STATCOM, to stabilize a critical induction motor which may be connected either locally at BESS terminals or remotely from it in a distribution network. Motor stabilization is successfully demonstrated during both charging and discharging modes of BESS operation. The BESS-STATCOM can provide dynamic voltage control 24/7 utilizing the entire BESS converter capacity for reactive power modulation. The proposed technique provides a new revenue making opportunity for BESS to provide critical motor stabilization service through reactive power control while performing its normal active power based functions.

Name: Somayeh Mokhtari
Name of Supervisors: Fiona Fang and Xianbin Wang

Channel Estimation and Resource Allocation for RIS-Assisted Vehicular Networks: A Full-Duplex P-NOMA Approach

Ensuring consistent and reliable communication in vehicular networks is challenging due to the high mobility of vehicles. To address this issue, this study presents a solution involving spectrum reuse, effective interference management, and adaptive channel estimation tailored for dynamic vehicular environments. This paper proposes an innovative communication model featuring full-duplex transmission and non-orthogonal multiple access (NOMA) that enhances spectrum efficiency and effectively tackles interference, a major issue in highly mobile settings. Specially, optimizes spectrum reuse between cascade channel, base station (BS)-reconfigurable intelligent surface (RIS)-vehicle, and vehicle-to-vehicle (V2V) communications, improving vehicular connectivity with limited spectral resources. Moreover, an imperfect channel is also regarded as a more realistic scenario. To tackle the complexities of channel estimation in RIS-assisted vehicular networks, our research designs a two-phased channel estimation methodology, which significantly reduces overhead while ensuring accurate channel estimation. In the initial phase, a duplex pilot transmission is employed to estimate the stable segment of the channel between RIS and BS. Building upon the estimated RIS-BS channel, the subsequent phase employs a crafted pilot signal to estimate the cascade channel. Furthermore, the paper delves into optimal power allocation and optimizes RIS phase shifts to achieve the maximum data rate within quality of service (QoS) constraints. The comprehensive simulation results demonstrate that the proposed approach outperforms existing techniques.

Name: Ali Rabiei
Area of Research: Power Systems Engineering
Name of Supervisor: Firouz Badrkhani Ajaei

Improving the Dynamic Behavior and Stability of Virtual Synchronous Generator-Based Microgrids
There is a need for a robust, effective, and stable control strategy that dampens active power oscillations in Virtual Synchronous Generator (VSG)-based grid-forming (GFM) converters when serving islanded host microgrids in the event of disturbances such as load changes, faults, etc. The existing decentralized control algorithms either fail to effectively dampen the active power oscillations or are only suitable for some specific topologies.

In this seminar, a generalized small-signal model of a VSG-based microgrid will be presented. Following this, the results of time-domain simulations, eigenvalue analysis, sensitivity analysis, and participation factor analysis—both with and without the presence of traditional and proposed power oscillation dampers (PODs)—will be discussed.

Name: Gabriella Gerges
Area of Research: Software Engineering
Name of Supervisor: Abdallah Shami

A Penetration Testing Framework For Open Source Electric Vehicle Charging Stations using the MQTT Protocol
The rapid escalation in Electric Vehicle (EV) adoption has necessitated a parallel expansion in charging infrastructure, leading to the emergence of open-source Electric Vehicle Charging Stations (EVCS). While these systems facilitate standardization and scalability, they introduce distinct cybersecurity challenges due to varied communication protocols and increased attack vectors. This research aims to devise a specialized penetration testing framework for open-source EVCS, focusing on identifying, analyzing, and mitigating potential cybersecurity risks to enhance the resilience of this critical infrastructure. Through a comprehensive analysis of operational dynamics, risk identification, development of a simulated testbed, and the creation and application of a targeted penetration testing framework, the study seeks to establish robust cybersecurity protocols. The anticipated outcome is a significant reduction in the vulnerability of open-source EVCS to cyber threats, ensuring the security and reliability of the EV charging network, which is vital for supporting the global shift towards sustainable transportation.

Name: Doaa Ashmawy
Area of Research: Microsystems and Digital Signal Processing
Name of Supervisor: Arash Reyhani-Masoleh

New hardware implementations of composite field AES

We propose and design three new hardware architectures for the composite field AES algorithm. The composite field is used for the whole round of AES encryption to reduce the critical path delay. To address varying levels of parallelism, we design the composite field AES round for three distinct data path widths: 32-bit, 64-bit, and 128-bit, while eliminating the need for external reordering of input and output bytes.

Furthermore, we propose and design three new hardware modules for the composite field key expansion with varying data path widths, enabling on-the-fly key generation. These expansion units generate 4, 8,and 16 bytes of composite field key data per clock cycle, contingent on the data path width. We present and compare the Application-Specific Integrated Circuit (ASIC) implementation results of the novel composite field AES schemes and compare to prominent previous work.

Name: Patrick Adjei
Area of Research: Software Engineering
Name of Supervisors: Miriam Capretz

Approximating Prospect Theory with the Hyperbolic Tangent Function for Risk-Averse Agents

One branch of safety in reinforcement learning is through integrating risk sensitivity within the Markov Decision Process framework. The objective is to mitigate low-probability events that could lead to severe negative outcomes. Eliminating such risky events is usually done by incorporating a utility function on the expected return; therefore, reshaping the reward structures according to the risk levels associated with different outcomes.

Additionally, the temporal difference learning algorithm can be modified with a utility to capture risk. Most notably, such utility functions are either convex or concave depending on the desired risk behavior. Depending on the outcome space, concave utilities may promote risk-averse behavior and convex utilities may encourage risk-seeking strategies. This is demonstrated in prospect theory graphs as a utility, where an ideal agent is risk-averse on gains and risk-seeking on losses. Unfortunately, the base formulation of the prospect theory graph is not Lipschitz continuous, which is problematic because it cannot assert convergence for value-based algorithms. This results in extensions of the base formulations to rely on local convergence or convergence under strict conditions. A novel approach is proposed in this paper using the hyperbolic tangent to approximate the prospect theory graph. Given that the degree of Lipschitzness is bounded to 1, with minor conditions, value-based reinforcement learning algorithms demonstrate global convergence in the formulated function domain. In addition, there are diminishing marginals associated with the prospect theory graph which is made more apparent in the proposed formulation. This