Master's Thesis Information Showcase
Spring Semester-2026
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	Department: Electronics Engineering Programme: Masters in Engineering Specialization: Micro system Design
1	**Title of the Thesis** Design and Implementation of Phase Locked Loop for Software Defined Radio (SDR) Transceivers
2	**Abstract** (min 300 to 500 words) Innovative research and revolutionary growth in a particular technology domain is driven by the end-user demands, applications and its market impact. Miniaturization, dynamic re-configurability and ease of implementation are prominent features of a Software-Defined Radio platform. The goals of compactness and small form factor cannot be achieved without the high-tech developments in Integrated IC design. The Field Programmable Analog arrays (FPAA) are in the evolution process of research and development since 1990s. But due to the popularity of Digital Communication systems, much of the research work is being carried out on Field Programmable Gate Arrays (FPGAs). FPGAs have been a promising platform for complex hardware implementation being rich in resources in terms of speed, memory and processing capabilities. The manufacturing of Application Specific Integrated Circuits (ASICs) with analog based hardware approach, is critically important because it provides greater advantage in terms of bandwidth and noise immunity and provide a hardware-resource efficient interface with analog RF front-end without requiring ADCs and DACs. Typically, ASICs require a time-consuming tedious design and development of a functional hardware and a design team to work on it. In this scenario, for development of analog based systems, a simpler implementation platform is of pivotal importance; Configurable-from-Software and Ready-to-Program Devices/ICs. FPAAs were introduced along with FPGAs, but their low processing capabilities did not attract the user market towards their utilization. With the advent of FPAA SoCs, manufactured in hybrid semiconductor analog and digital fabric, the market trend is shifting towards FPAA platform as alternate approach to ASIC design. These FPAAs provide a low-cost solution

	to address the challenges faced by FPGA resource hungry design implementation while offering comparable processing resources. This thesis work is based on the design and development of Phase Locked Loop for Radio frequency synthesizers. Most of the work carried out on FPAAs up till now, comprises of AI-based algorithms for sensor data acquisition, characterization and error compensation on small-scale technologies. Comparatively, a little research is carried out for the designing of Phase Locked Loops on FPAAs due to vendor-specified functional blocks with software and hardware limitation. In view of the above, a novel strategy is outlined for the hardware implementation of PLLs on FPAA platform to meet the end-user requirement in the lower frequency ranges of Radio Frequency spectrum. The design approach starts with the proposed architecture of second-order Type-I PLL and its critical functional modules implemented by Op-Amp based analog functions. In this way, behavioral depiction of individual modules is realized which includes phase-error detector, loop filter and Look-Up Table (LUT) based voltage-controlled oscillator (VCO) later replacing it with a more efficient hybrid scheme. The designed topology is modelled in MATLAB to work out for the loop dynamics that help characterize its critical performance keeping in view its phase margin and settling time. An equivalent phase domain model is evaluated to develop an agreement between the actual and simulated results for analysis of the proposed topology. In the next phase, second-order Type-II PLL is implemented to overcome the limitations of Type-I PLL in terms of stability to improve phase margin. Results are compiled in tabular form and improvements achieved are quantified to develop a baseline architecture of PLLs for high frequency synthesizers that can be utilized in compact RF systems to benefit from the analog signal processing capabilities of FPAAs. Design and validation of Phase Locked Loop (PLL) algorithm has paved the possibility for implementation of frequency synthesizers on this platform and is realizable to advanced versions of FPAA SoCs to meet end-user requirements.
3	**Impact on SDG#___"** (min 500 words) (Please mention the impact of the relevant attained SDG)

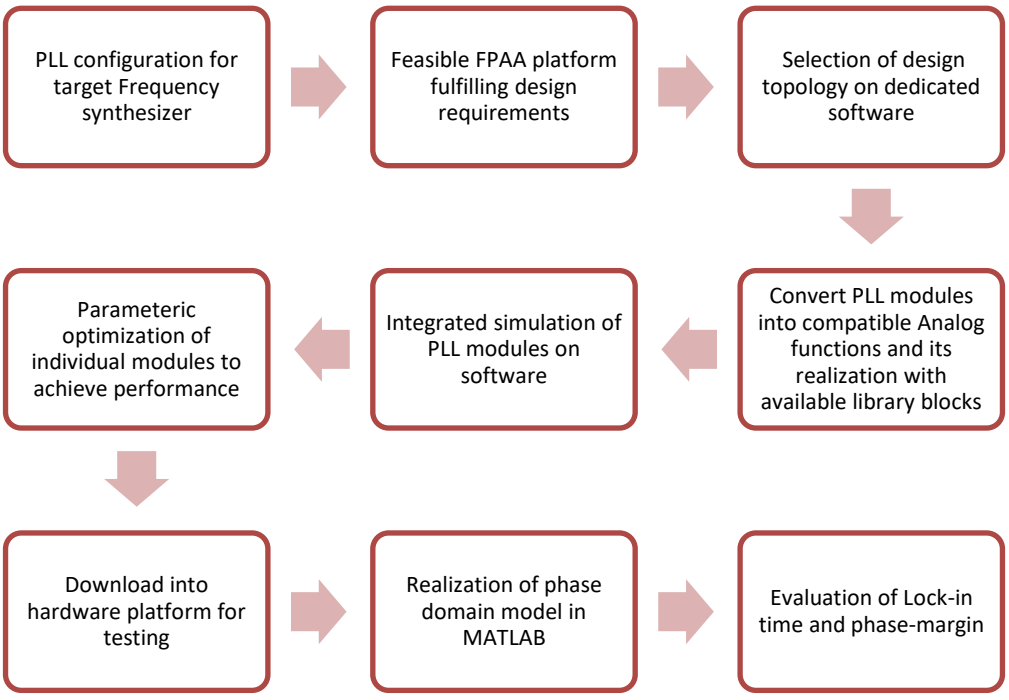
Field Programmable Analog Arrays (FPAAs) are emerging as an innovative technology in modern electronics because they provide a flexible platform for designing, testing, and implementing analog circuits without the need for manufacturing new hardware for every design modification. Unlike traditional analog integrated circuits, which require fixed architectures, FPAAs can be reconfigured through software, allowing engineers and researchers to realize circuit functions in compliance with end-user application requirements. This capability significantly reduces development time, lowers production costs, and accelerates innovation in various sectors such as healthcare, environmental monitoring, telecommunications and industrial automation. As the world moves toward sustainable technological development, the motives of FPAA technology aligns closely with the objectives of the United Nations Sustainable Development Goals (UN SDGs) by promoting innovation, improving resource efficiency, and supporting solutions for global social, economic, and environmental challenges. The key UN SDGs to which this technology might have a positive impact are:

- Good Health and Well Being (Goal #3)
- Affordable and Clean Energy (Goal#7)
- Industry, Innovation and Infrastructure (Goal#9)

The contribution of FPAAs to the UN SDG Goal#3 is evident from the advancement of technology growth in the field of quality healthcare and well-being. Medical devices such as portable diagnostic equipment, wearable health monitors, and biosensors require low-power and highly adaptable analog signal processing systems. FPAAs enable researchers to prototype and optimize these devices rapidly without repeatedly fabricating new hardware, thereby reducing development costs and making healthcare technologies more affordable. Their reconfigurable nature also allows medical equipment to be updated with improved algorithms and sensing capabilities without replacing the entire system, extending product life and reducing electronic waste. These innovations contribute to improved healthcare services, especially in remote and resource-limited regions where cost-effective diagnostic technologies can significantly improve patient outcomes.

Energy efficiency is an important dimension of FPAA technology that supports UN SDG Goal #7. Many FPAA devices operate with low power consumption, making them suitable for battery-operated and renewable-energy-powered applications such as wireless sensor networks, smart agriculture, and Internet of Things (IoT) systems. These energy-efficient designs reduce electricity consumption and extend battery life, thereby decreasing operational costs and environmental impact. In renewable energy systems, FPAAs can be employed for analog signal conditioning, control circuits, and adaptive monitoring, helping improve the efficiency and reliability of solar, wind, and other clean energy technologies. Their ability to adapt to varying operating conditions enhances overall system performance while supporting the transition toward sustainable energy solutions.

Another significant contribution of FPAAs relates to UN SDG Goal #9 in sustainable industrial development and innovation. The flexibility of FPAA-based systems enables engineers to do iterations with multiple analog circuit configurations using a single programmable platform, reducing the need for numerous prototype boards and specialized components. It not only minimizes material consumption but also decreases manufacturing cost and energy usage during the product development cycle. Faster prototyping accelerates research and development activities, encouraging innovation in electronics, embedded systems, robotics, and automation. By enabling efficient technology development, FPAAs strengthen industrial competitiveness while supporting sustainable production practices that are central to global development objectives.

In conclusion, Field Programmable Analog Array applications have significant potential to support the achievement of the United Nations Sustainable Development Goals. Their flexibility, re-configurability, energy efficiency, and cost-effectiveness enable innovations across healthcare, environmental monitoring, education, industry, renewable energy, and smart infrastructure. By reducing development costs, minimizing electronic waste, promoting sustainable manufacturing, and enabling efficient resource utilization. As research and technological advancements continue, the adoption of FPAAs is expected to play an increasingly important role in addressing global sustainability challenges and fostering advanced technological progress that benefits both present and future generations.

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6	**Graphical Abstract**