Static Transfer Switch

Progress Report 1

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A progress report 1 submitted in partial fulfillment for the final year Capstone Project in the Faculty of Engineering and Applied Science.

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Abstract

Switching plays an imperative role when it comes to Power Systems. Switching is the term used to change the configuration of the electric system or to provide isolation for safe working activities. Switching is required to open or close disconnect switches, circuit breakers, and for planned maintenance, emergency restoration, load transfer, and equipment isolation.

In this era of modern age we can't have power outage as everything we use is connected to electricity. These interruptions could prove to be very costly to the customers, especially industries which rely heavily on constant power flow to critical loads for the production of their products, hence we aim to design a transfer switch which could switch between loads in a seamless manner while maintaining efficiency

This report will highlight the current state of technology of the Static Transfer Switch and it which cases the Static Transfer Switch can be implemented. It will also highlight the process in which our team plans on moving forward with the capstone project.

This is the first report and therefore it will investigate the Static Transfer Switch from a high level and will create the foundation for further reports and prototype development.

Acknowledgements

We would like to express gratitude to our supervisor Dr. Vijay K Sood for giving us the opportunity to work on this project. His detailed suggestions and explanations have helped us greatly in developing this report.

We also would like to acknowledge Dr. Ramiro Liscano for organizing the capstone supervisors and for all of the helpful lectures on what was expected of us during this course.

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1 Project Scope

This project looks at the incorporation of Static Transfer Switch Technologies (STS) into both industrial and commercial systems to create a more robust and reliable power flow. The purpose of the STS is to minimize blackout times by seamlessly switching to an alternative power source when an issue regarding the main power source to the load is interrupted. This project will analyze the issues in the current STS technology and investigate how the current solutions can be both be improved upon and remain safe and reliable to the loads. The STS must be able to overcome include all mentioned in table 1 and shown in their waveforms in figure 1.

Table 1 Interruptions categorized by IEEE Standard 1159

Power Quality Issues of which the Static Transfer Switch will be implemented to solve		
Transients	Interruptions	Sag / Under Voltage
Swell / Over Voltage	Waveform Distribution	Voltage Fluctuation & Frequency Variation

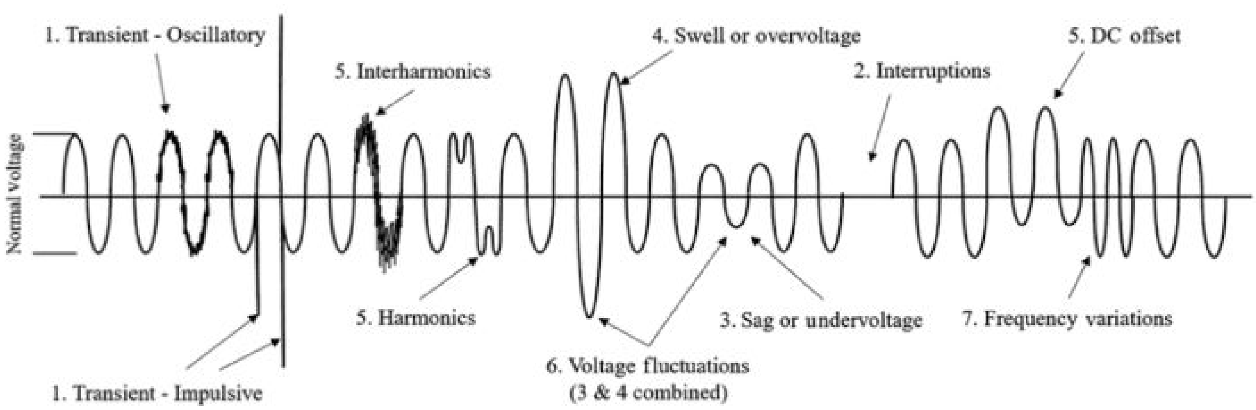


Figure 1 Waveforms of Power Quality Issues

2 Project Related Background and Research

Many power quality solutions have been engineered to avoid the inevitable power outage incident in utility, industry, and residential sectors. There has yet to be a more practical solution in terms of economical impact, reliability and universally accepted application than the latest generation of static transfer switches. Current generations of STS are capable of transferring megawatts in microseconds which is necessary when employing the STS to protect critical information found in telecommunications, computer networks and all equipment used for critical operation.

The purpose of a STS is to maintain electrical power to the load (often critical) by switching between two independent voltage sources. Typically the main source is fed in from the utility but the alternative source varies from a battery bank, generator, renewable source, or any other type of source capable of supplying the necessary power. The STS is able to sense power disturbances and automatically transfer the power flow from the main to the alternate source. These disturbances include but are not limited to; power outages, sags and swells, and interruptions. When done correctly, this switching between the two sources does not require any input from the user.

Static transfer switch (STS) technology has been utilised in the industry for over 30 years in low voltage configurations, typically under 480V. During the 1990s, new developments in the silicon field allowed for larger STS with the capacity of handling larger loads and larger voltages up to 38kV.

There are many different types of transfer switches that are used in the marketplace for different applications. These switches include the open transition transfer switch, closed transition transfer switch, soft loading transfer switch and of course the static transfer switch. Depending on the application in which the STS is implemented it will appear different but it is generally composed of three main components: two ac thyristor switches, mechanical bypass switches/breakers, and mechanical isolating switches/breakers. The thyristors allow for rapid switching between sources by first stopping current flow from the main source, then allowing current to power the load from the alternate source. The switch between the two power sources can be executed as fast at 2.5 ms for loss of voltage or 12 ms for voltage swells. This variant between times is due to the ac sine wave must reach 0 V for the thyristor to stop conducting.

2.1 Project Related Review of the Current State of the Art

The implementation of the STS is of great interest to electrical engineers globally. Currently the greatest implementation of the STS is in commercial and industrial sectors of the market. These sectors often contain critical loads and servers containing sensitive information that requires constant power to maintain functionality and decrease the probability of expensive outages.

A previous solution to this issue was the integration of electromechanical switchgear which could take anywhere from 2 to 10 seconds to switch between power sources. This solution no longer meets the threshold of critical equipment for most consumers. Businesses have become dependant on devices such as; computers, telecommunication devices, adjustable speed drives, causing reliability and seamless protection provided by the STS.

Switch energy loss with an STS is considerably less than with many other power quality solutions. With a 15kV switch, the thyristors provide power dissipation efficiency between 99.7 to 99.9%. The switch offers on-line efficiency that is nearly thirty times better than that offered by many UPS systems, which can be as low as 70-80% efficiency end-to-end. A practical alternative to UPS and backup generator systems, STSs offer improved system reliability, reduced downtime and increased productivity.

2.1.2 Industrial Application

Today, the largest STS in commercial service (38 kV) was installed at the Visteon facility in Lansdale, Pennsylvania. Prior to the installation of the STS, the factory was experiencing as many as 17 power quality disturbances per year causing a complete shutdown of production. The solution was installing a 38V, 600A, 6kA fault duty STS integrated with a Powercon metal enclosed bypass switchgear package. Since the switch was installed, the company has not experienced any further power interruptions.

2.1.3 Telecommunication Application

Hydro One is the largest power distributor in the province of Ontario and with that comes the burden of having millions of consumers relying on their system to provide power to their home or business every minute of every day. Within every substation across the province telecommunications are required for supervisory control and data acquisition (SCADA) to ensure the substation remain operational and secure. SCADA is critical to operation and thus requires power without interruption. STS are utilized to ensure switching from primary source to locally housed dc batteries seamlessly to assure constant power. The towers containing these switches can be viewed in image 2 below.

Figure 2 Charger Towers use STS to connect to primary and alternative sources

2.1.4 Next Generation Static Transfer Switch

The new generation STS is designed for large loads, with ratings as high as 5,000A for 480V systems and 1,200A for 27kV systems. They also feature ample fault current withstand ratings up to 100kA for 480V, and 18kA for 15kV and for 27kV. The STS is available in either a preferred/alternate or split bus configuration. As technology progresses so will the specs and capabilities of the STS and with that more application of the STS will be feasible.

2.2 Project Definition

The STS is a technology that is functioning optimally when it is completely undetectable. Currently the larger markets for STS are industries with sensitive data and critical loads but this may change as renewable energy becomes more reliable and economically feasible for the everyday consumer. Since renewable energy technology has yet to reach this feat, our project will focus on creating a solution to an industrial/utility customer. Figure 1 demonstrates at a high level the functionality of the STS in regards to main power, alternate power and load.

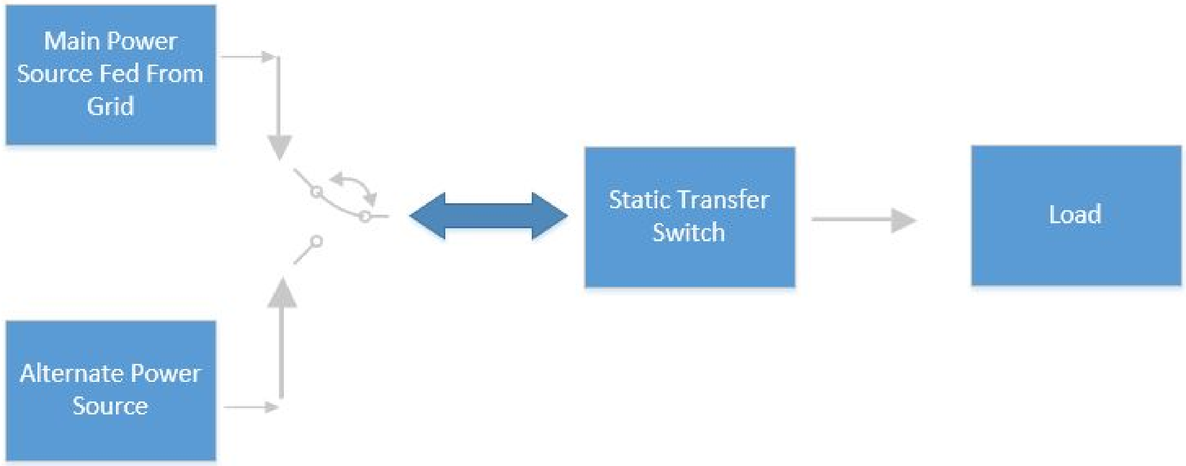


Figure 3 High level overview of implementation of Static Transfer Switch

3. Design Process

The success of any project is related to the ability of the project team to follow a design process. Our design process identifies:
a. the overall flow of activities, actions, and tasks and the interdependencies among them
b. the degree to which work products are identified and required
c. the manner which quality assurance activities are applied
d. the manner in which project tracking and control activities are applied
e. the degree to which the customer and other stakeholders are involved with the project
f. the degree to which team organization and roles are prescribed 12 Delivering Capstone Design Courses at FEAS

a) The capstone group came together in the summer of 2018 in order to build a team environment that going forward will benefit everybody as we learned strengths and weaknesses of one another during that time. Unfortunately, the very first hurdle that the group faced in the first week of capstone was that a member of the group got accepted for an internship and thus had to drop out of the course. This was a major drawback for the group as now the group went down to 3 from 4 and had to distribute programming part of the project to another member that was slightly stronger at programming than the rest of the group. This will mean more hours will be allocated to learning how to code but it's a step in the right direction as the 3 members are working together closer than ever in order to deliver the report. The tasks were assigned to each member of the group and they were independent of each other in order to be efficient.

b) Work products are identified as per the descriptive Engineering Design process shown in figure 4. It embodies the steps required to take an idea from concept to realization of the final system, and are problem-solving methodologies that aim to develop a system that best meets the customers' need within given constraints.

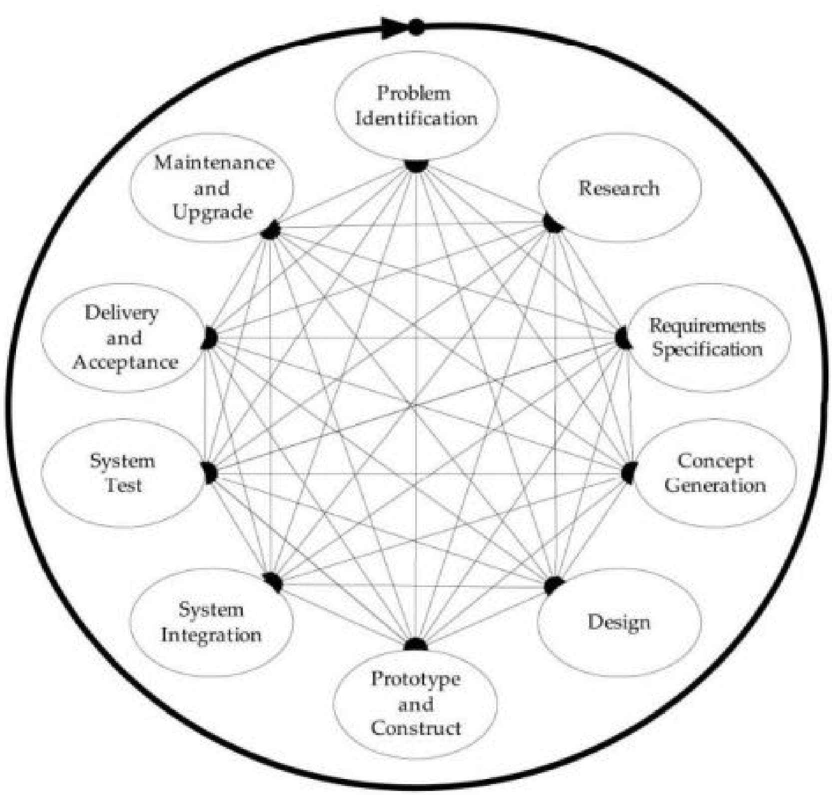


Figure 4: Engineering process web

c) We applied quality assurance by following a template of a QAQC Checklist. This was done on a weekly basis by a Team leader to ensure that the documentation done during that week has been properly formatted and indents with the overall look of the report. Secondly, we made sure the research methodology was used which is prescribed in section 2 of this report i.e; What is the basic theory behind the concept? How is it currently being done? What are the limitations of current designs or technology? What are the similarities and differences between your concept and existing technologies? Are there existing or patented technologies that may be relevant to the design? If so, what are they and why are they relevant? Apart from this, the project leader of that week made sure the resources utilized were specialized websites designed for our project i.e; EE Product Center, IEEE,,etc. The project leader also made sure the test plan that was discussed with Advisor is still being following and that the timeline is being met by the team.

Table 2 QAQC Checklist

	QAQC Checklist		
#	Checklist	Version #	Author
Documentation format		X.x	Document Owner
Research Methodology Utilized		X.x	Document Owner
Test Plan		X.x	Document Owner
Project Management		X.x	Document Owner

d) Project Tracking was done through the use of Microsoft Project while Project Monitoring and control was done via the use of Github as it was utilized to make sure equal contribution from all team members was made.

e) Basic Chevron Process (figure 4) is used to shown below the involvement of customer with stakeholders of the project as weekly meetings were held to ensure the final deliverable will meet customer's expectations and requirements

Figure 5: Chevron Process Breakdown

f) The roles of each member were rotated on a weekly basis since the start of this project as this ensured all group members were given equal opportunities to step up to the task and goals in order to complete this report. This is shown in Table 2 below.

Table 3 Team Roles and Schedule

Prescribed Team Roles						
	Week of Sep 10	Week of Sep 17	Week of Sep 24	Week of Oct 01	Week of Oct 08	Week of Oct 15
Project Leader	Colin	Colin	Hamza	Danish	Danish	Hamza
Engineering Leader & Report Editor	Hamza	Danish	Danish	Colin	Hamza	Colin
Research Developer	Danish	Hamza	Colin	Hamza	Colin	Danish

4. Scenarios and/or Use Cases

STS are implemented to protect loads and entire facilities and can be introduced as a stand alone systems or can be implemented in partnership with critical equipment. STS can be found across all industries in which there are critical loads or sensitive information that cannot be lost.

Table 4 Applications of Static Transfer Switch

Applications in which Static Transfer Switches are Used		
Internet Data Centers	E - Commerce	Telecommunication Centers
Network Operation Centers	Fibre Optic Never Centers	Airport Security System
Power Generation Plants	Automated Manufacturing	Industrial Parks
Hospitals	Process Control	Data Centers

In the future, as renewable energy sources overcome storage issues and become affordable for the majority of consumers, the STS could become an integral part of every home. The current method of residential generation requires the energy generated from the home be fed into the grid and does not allow for the consumer to use the energy they are producing. One method of cutting down emissions could be for the home to use their own generated power as their main source and the grid as their alternative. If this ever becomes the reality, STS will play a crucial role and will be universally required.

5. Stakeholder Requirement and Traceability Matrix

Table 5 Engineering and Marketing Requirements

Marketing Requirement	Engineering Requirement	Justification
1,2	System should detect faults and transfer should happen within 30 cycles for 60Hz electricity.	All the faults including (Transients, Interruptions, Sag / Undervoltage, Swell / Overvoltage, Waveform distortion,Voltage fluctuations Frequency variations) should be detected and the switch should happen in a timely manner
5,6,7	System should retail at a median market price while providing easy instructions for installation	Installation cost should be cut down providing the installer needs no extra training to install our system.
4,6,7	Should be able to handle voltage up to 30kVA while minimizing internal power losses (upto 97% efficient).	System should be able to handle larger voltages
3,6,7	The system should work in 3 phase while complying with ESA regulations	System should be safe to operate/install and should match all the properties of the load to the source.

Marketing Requirements

1. Should be able to changeover between the grid and alternative backup power supply.
2. The load should be supplied seamlessly from alternative sources.
3. Should have a low failure rate
4. Should be able to handle large power sources
5. Should be Versatile
6. Should be Energy efficient (Low internal power losses)
7. Should be safe to use

6. Definition of Acceptance Tests

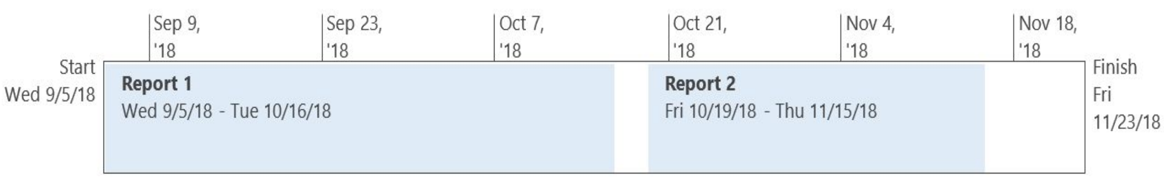
Currently at this stage of the project it is difficult to define acceptable metrics. As progress is made into the project the list or required metrics will increase so will the quantitative requirements. A high level chart of requirements is shown below in table 6.

Table 6 Acceptance Tests

Acceptance Tests	Pass	Fail
Switch is capable of seamless transition between two sources		
Switch does not create new independent power quality issues		

7. Project Plan

The purpose of this detailed project plan is to ensure that deadlines are met. The schedule will structure the time spent on the project in an efficient manner. This schedule outlines the amount of time that will be put into each aspect of the project. As shown on the next page, more time will be required for the tasks that are more difficult and time consuming.



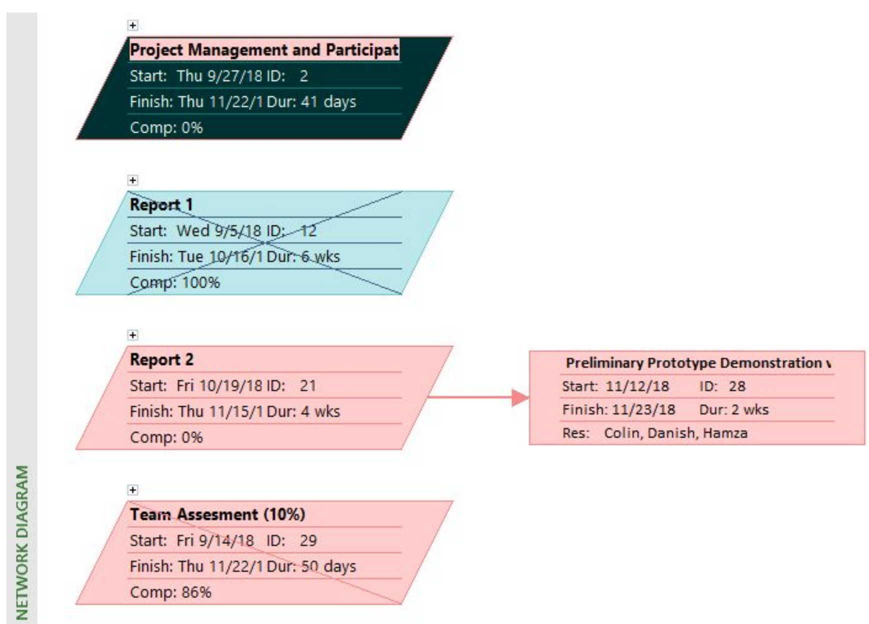


Figure 6 Network diagram detailing work to be done

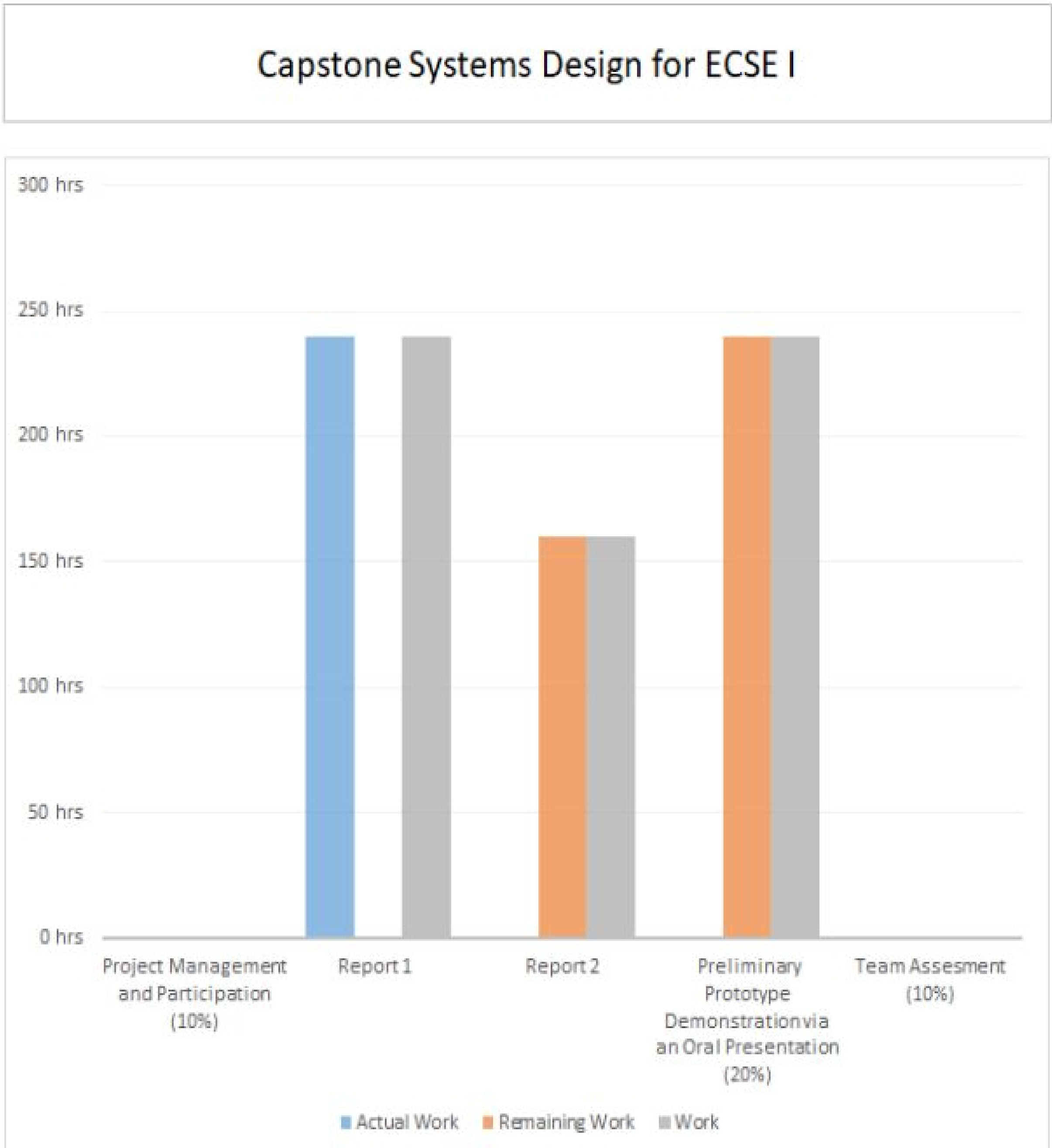


Figure 7 Chart detailing time spent on work and time remaining

8. Contribution Matrix

Table 7 Contribution Matrix

Required topics	Topics assigned	Duration	Reviewed by	Date finished
Problem Identification	Hamza	3 days	Colin	09/28/2018
Project-related Background and Research Review	Colin	4 days	Danish	10/02/2018
Design Process	Danish	3 days	Colin	10/06/2018
Scenarios and/or Use Cases	Colin	2 days	Hamza	10/09/2018
Stakeholder Requirements and Traceability Matrix	Hamza	4 days	Colin	10/12/2018
Definition of Acceptance Tests	Colin	3 days	Danish	10/14/2018
Project Plan	Danish	2 days	Hamza	10/16/2018

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Appendix A Gantt Chart

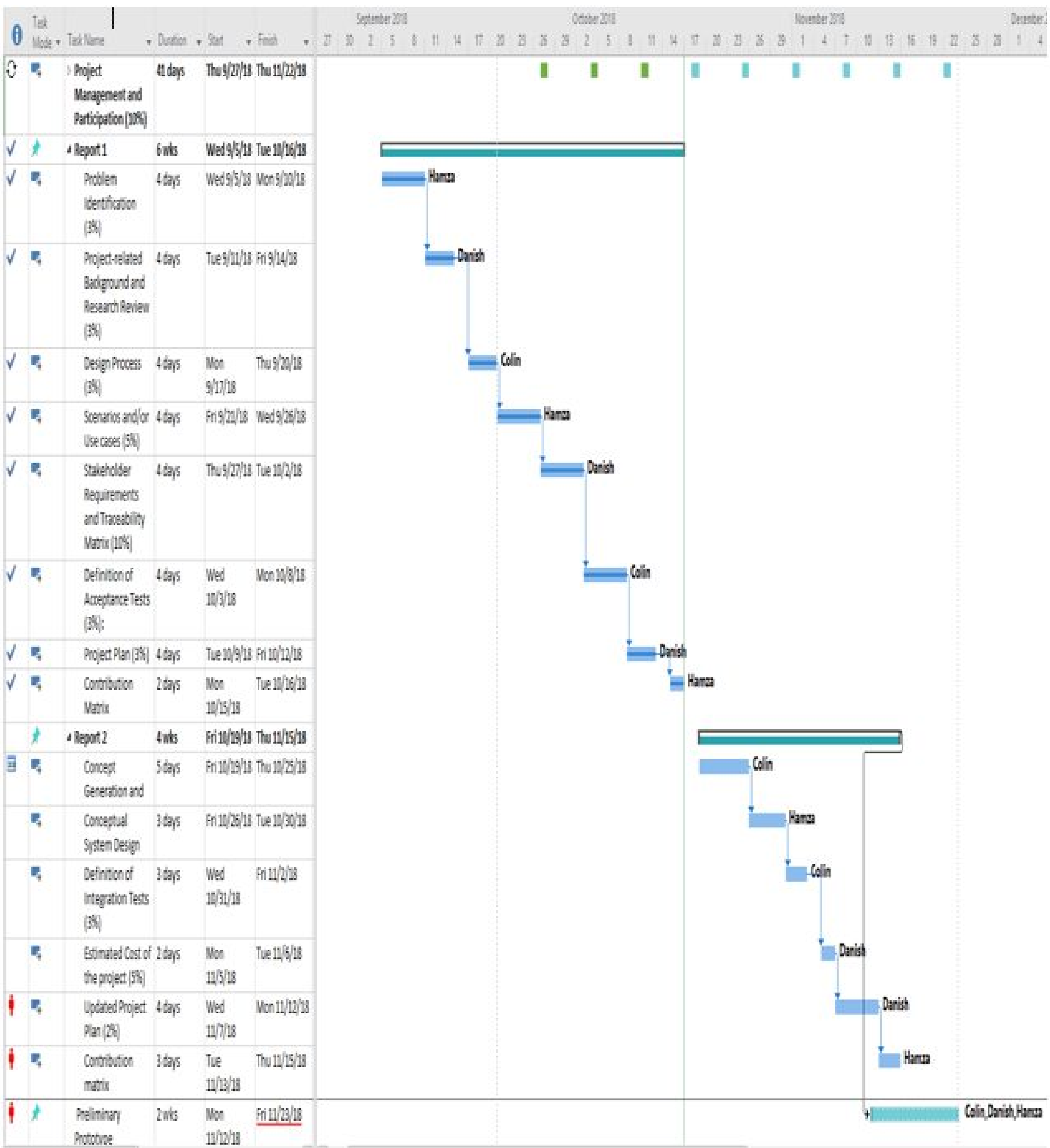

Figure 8 Gantt Chart