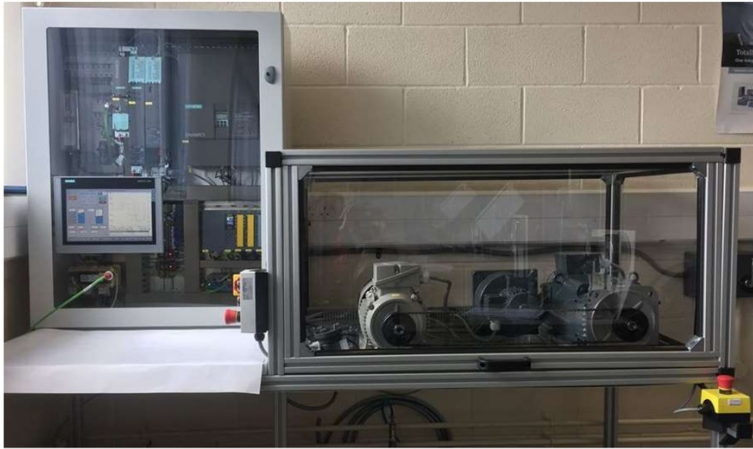


Presentation 2

by Liesel Williams

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PSDE 6019

Major Project

2018-2019

Presentation 2

Liesel Williams

1. Aims and Objectives

Provide an AC/DC motor generator set for teaching Electrical and Electronic Engineering modules at Levels 3 through to 6.

Bespoke design using the latest Siemens Drives, PLC, HMI and Software.

Cover extended learning i.e. load testing, control systems design, loop tuning, networking, Matlab model verification.

For this project the FDS scope was:-

Demonstrate AC 4 quadrant operation

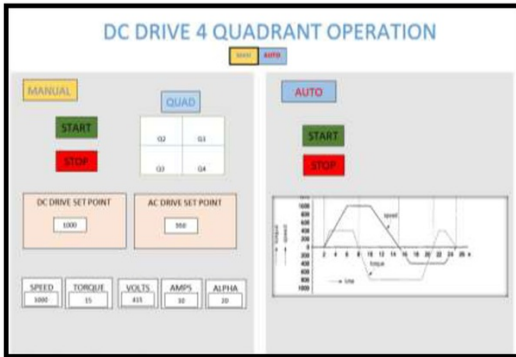
Demonstrate DC 4 quadrant operation

DC speed control using field weakening

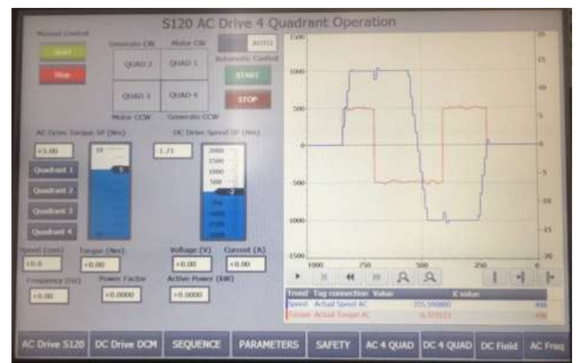
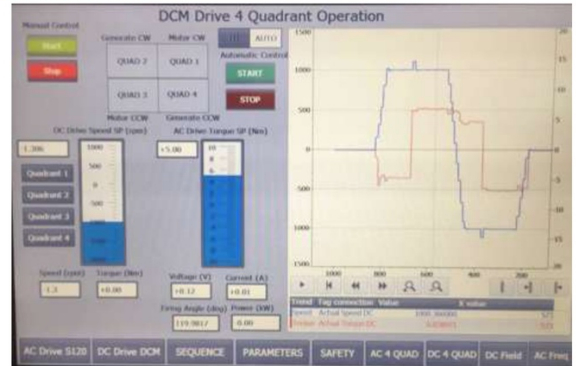
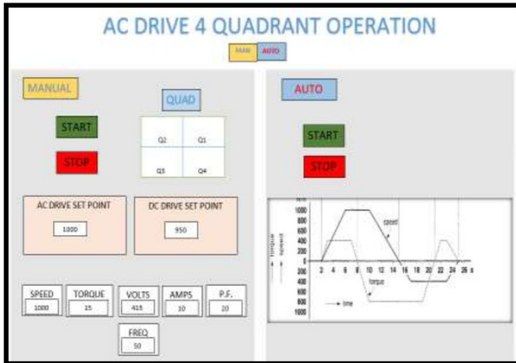
AC speed control using inverter drive

2. Functional Design Specification

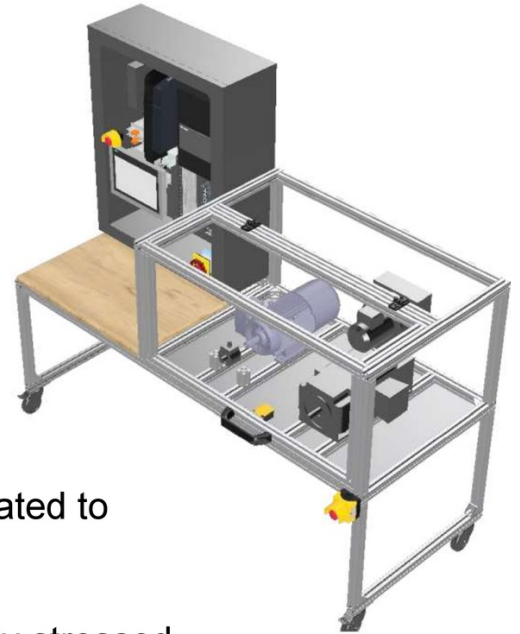
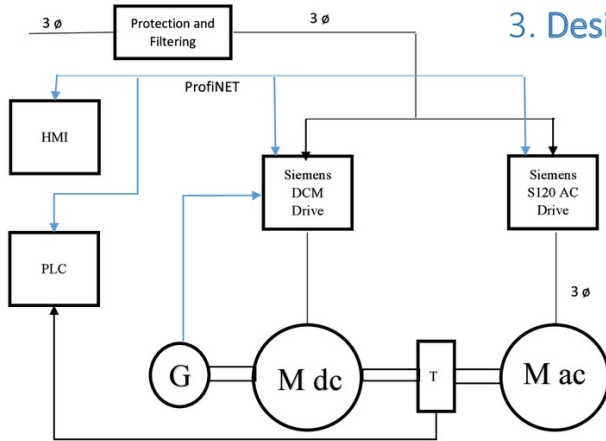
HMI 1



HMI 3



3. Design Details of Solution



The original concept is shown in block diagram form.

Lots of research needed into motor drives.

Specification of main parts and application communicated to supplier.

Agreed price and FDS.

Learning opportunity - Delivery deadline not sufficiently stressed to avoid delays in receiving item.



4. Construction of Solution

Key	Component
1	AC drive 3 pole protective device (MCB1)
2	DC drive 3 pole protective device (MCB2)
3	DC Field 2 pole protective device (MCB5)
4	230V PSU 2 pole protective device (MCB4)
5	SINAMICS S120 CPU (CU1)
6	SINAMICS S120 Smart Line Module 5kW Regenerative (1T1)
7	SINAMICS S120 Single MOMO Motor Module (1T2)
8	SINAMICS Stormrichter DCM (2T1)
9	SINAMICS S120 Line filter (R9)
10	DC Fan 3 pole protective device (MCB3)
11	3 pole DC Fan Relay (K1)
12	SINAMICS S120 Sensor Module for Incremental Encoder (SMC30)
13	SINAMICS S120 Line Reactor (R4)
14	Commutating reactor for converter (R7)
15	S120 Motor Inductor (R6)
16	24V Fuses
17	Connector Blocks
18	DC Enable Relay (K2)
19	Common ground connector block
20	Ethernet Switch (SW1)
21	Power Supply S7-1500 (PSU1)
22	PLC S7-1500 F series CPU (PLC1)
23	F-DI 16x24VDC Digital Input Module (A1)
24	F-DQ 8x24VDC/2A Digital Output Module (A2)
25	AI 8x U/I HS Analogue Input Module (A3)
26	Door mounted Isolator switch (Q1)
Door mounted	TP1200 Touch 12" (HMI1)

5. Testing, Analysis, Maintenance and Reliability

HMI 1 - DC drive 4 quadrant operation								
Manual					Auto			
Quad	Va (V)	Ia (A)	N (rpm)	Tm (Nm)	Quad			
1					1	2	3	4
2					Tracer Graph (Y/N)			
3					Data Upload			
4					Va	Ia	N	α

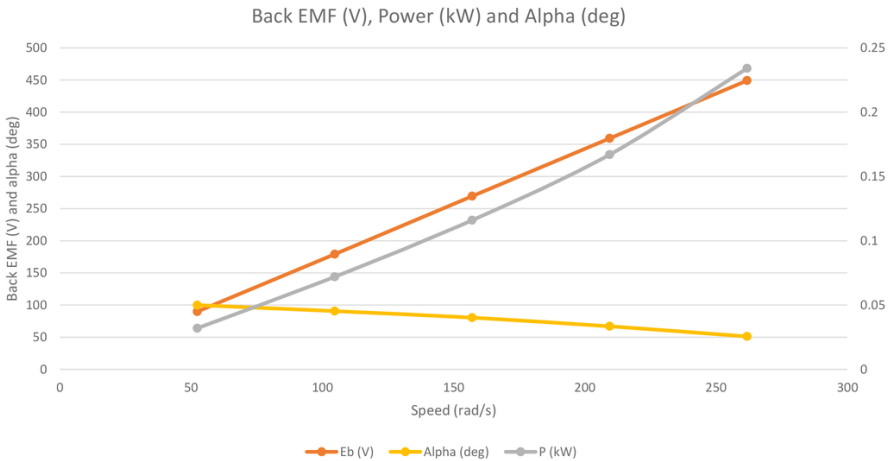
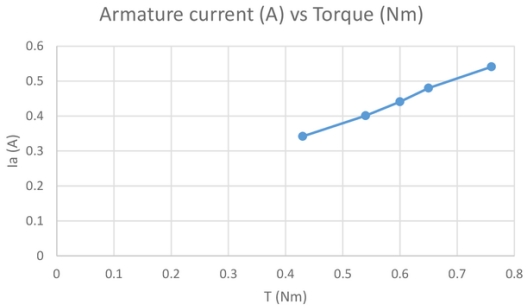
HMI 3 - AC drive 4 quadrant operation								
Manual					Auto			
Quad	Va (V)	Ia (A)	N (rpm)	Tm (Nm)	Quad			
1					1	2	3	4
2					Tracer Graph (Y/N)			
3					Data Upload			
4					Vdc	Is	N	fs

	Quad	Vav (V)	Ia (A)*	N (rpm)	Tm (Nm)	P(kW)	α (deg)	Eb (V)	Va (V)
Function		r52292	r27	r61	r80	r32	r50018	r50037	r50038
Fwd Mot	1	146.6	5.22	1000.3	6.69	1.02	68.75	178.1	196.3
Fwd Gen	2	121.41	-3.77	996.8	-4.92	-0.62	107.85	179.3	165.1
Rvs Mot	3	-146.3	-5.11	-1000.1	-6.68	1.01	68.57	-178.9	-197.4
Rvs Gen	4	-120.7	3.78	-1000.1	4.95	-0.62	107.76	-177	-164.3

	Quad	V (V)	I (A)* r27	N (rpm)	Tm (Nm)	P(kW)	pf	f(Hz)
Function		r25	r27	r22	r31	r32	r38	r24
Fwd Mot	1	250.9	3.08	1003.1	6.69	0.694	0.64	33.97
Fwd Gen	2	233.29	3.13	1003.5	-6.85	-0.683	-0.59	32.81
Rvs Mot	3	257.01	3.1	-1002.2	-6.8	0.691	0.65	-33.89
Rvs Gen	4	233.01	3.13	-1003	6.79	-0.691	-0.59	-32.95

DCM Off load

Calculated values from measured data														
N (rpm)	w (rad/s)	T (Nm)	Eb (V)	P (kW)	Alpha (deg)	Alpha (rads)	Ia (A)	If (A)	V av (V)	ke	km	cos alpha	Pm (W)	Ploss (W)
500	52.36667	0.43	89.838	0.032	99.88	1.743460889	0.342	18.649	67.82	1.715557	1.25731	-0.1718079	22.51767	9.482333
1000	104.7333	0.54	179.159	0.072	90.55	1.580600556	0.401	18.666	134.78	1.710621	1.346633	-0.0098041	56.556	15.444
1500	157.1	0.6	269.342	0.116	80.35	1.402553889	0.441	18.668	200.02	1.714462	1.360544	0.16744986	94.26	21.74
2000	209.4667	0.65	359.227	0.167	66.929	1.168282878	0.48	18.664	266.73	1.71496	1.354167	0.39173215	136.1533	30.84667
2500	261.8333	0.76	449.147	0.234	51.257	0.894719411	0.541	18.674	332.23	1.715393	1.404806	0.62573771	198.9933	35.00667



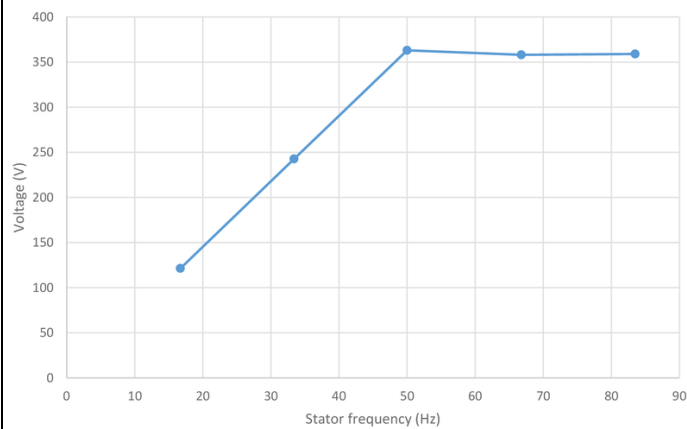
S120

Off load

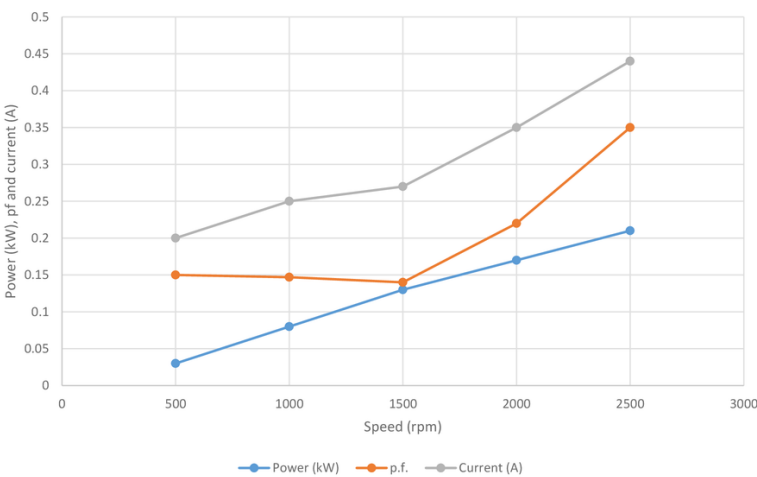
N(rpm)	Torque (Nm)	frequency (Hz)	Voltage (V)	DC Link (V)	Power (kW)	p.f.	Current (A)
500	0.6	16.7	121.3	600	0.03	0.15	0.2
1000	0.8	33.4	242.6	595	0.08	0.147	0.25
1500	0.84	50	363	592	0.13	0.14	0.27
2000	0.81	66.78	358	590	0.17	0.22	0.35
2500	0.82	83.5	359	589	0.21	0.35	0.44

V/f	T/I
7.263473	3
7.263473	3.2
7.26	3.111111111
5.360886	2.314285714
4.299401	1.863636364

Voltage vs frequency



Power, pf and current

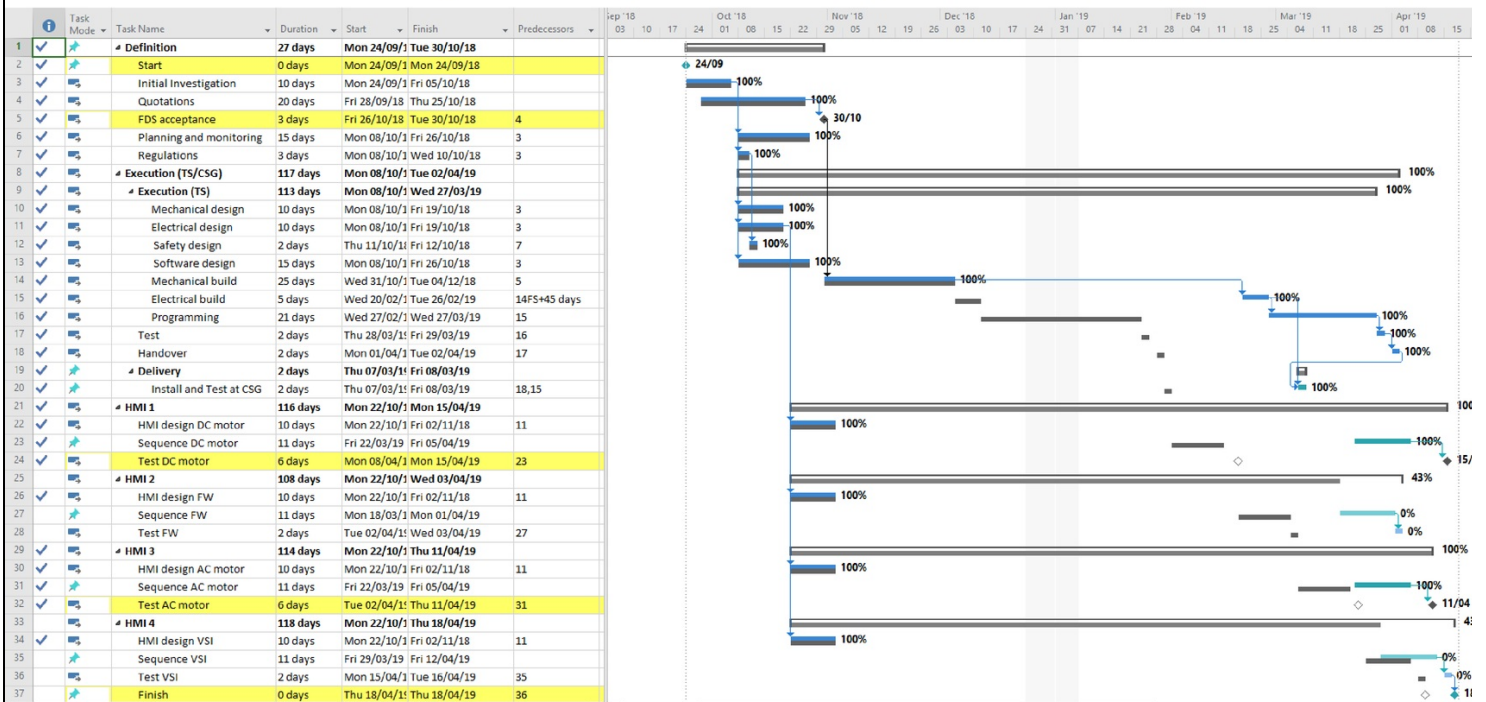


6. Critical Evaluation – Degree of Risk

Negligible	Very Low	Low	Significant	High	Very High	Extreme	Unacceptable
0-1	>1-5	>5-10	>10-50	>50-100	>100-500	>500-1000	>1000

Hazard – injury due to....	DoR	Control	DoR	Actioned	Comment
Potential failure of Safety Control System (HMI)	20	Push button start and stop added	0.66	Yes	Not needed due to EStop
Estop incorrect shroud and location	20	Replaced and repositioned	0.33	Yes	Palm operation
Overriding interlock and access to drive belt	20	More securely fixed	0.66	Yes	Security screws fitted
Nameplate does not contain relevant information	5	New label fitted	0.33		(Voltage, current, power, weight, dB)
Earthing arrangements and electrical safety test	7.5	Suitable, labelled earth terminal and earth bonding to door	0.33	Yes	Awaiting results of tests EN60204-1:2006 clause 18
Noise	10	Measurement	0.33	Yes	85dB
Lack of instructions	20	Instruction manual	0.33		WiP

7. Project Management Techniques and Planning

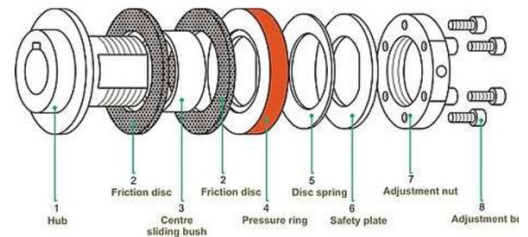


8. Conclusions and Recommendations

Overall successful completion to be celebrated, the rig functions, results of tests are accurate and have proved basic motor theory.

Lots to learn about drive configuration and telegrams opening up a host of new experiments.

Safety limits and safeguards preventing misuse will need to be added to the program e.g. **It is important that when in Torque mode the DC drive is on and has a speed set point to hold the torque.** If the DC drive is off the AC drive will try to reach torque set point under no load and the motor will run away!
This is an important safety addition and one which should be priority before allowing students to use the rig.



Torque Limiting Coupling

Presentation 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

80/100

Instructor

PAGE 1

PAGE 2

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PAGE 5

PAGE 6

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PAGE 8

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GRADING FORM: NEW CSG-RUBRIC

LIESEL WILLIAMS

80

1. ENGAGEMENT WITH LITERATURE

 Evidence was provided in reference to motor and drive data. The use of technical literature was evident in the testing explanation. (4/10)

4

2. KNOWLEDGE AND UNDERSTANDING

 A good introduction to the main aims and objectives specific to the project. The project was confidently introduced and the aims/objectives stated. The original FDS was reviewed clearly with expected outcomes stated and deviations from the original were explained. Clearly demonstrated throughout the presentation on all aspects of the project. It was clear which parts of the final product were sub-contracted and how much was built locally. An opportunity exists to develop the rig as a sellable commodity, it would be a risk not to engage with IP and protect the design. Good, well thought out answers given to questions, very good knowledge demonstrated on the wider issues such as public perception and aesthetics, legal requirements namely safety and CE marking, good consideration of IP rights and potential for further development. All questions posed by the panel were answered confidently and demonstrated excellent knowledge of the project and the wider issues associated with it (24.5/30)

24.5

3. COGNITIVE AND INTELLECTUAL

 Good evidence provided from HMI screens and recorded data with graphical analysis. The testing section was well explained and the presentation included slides of the results graphs etc. An excellent evaluation of the project was given and any problems and deviations were explained. Very good set of conclusions for the project outcomes with a good statement for percentage completion and clear recommendation for further development. There are still issues to be resolved both in terms of functionality and quality and the proposed solutions to these were explained. (23/30) **23**

4. PRACTICAL APPLICATION

 Solutions provided for most of the aspects of the project using an innovation and creative approach in the development of the solution. Some aspects of the FDS were not completed or partially completed. Important modifications were carried out in hardware and software. The final product used good quality components with some recycling of refurbished motors. The use of regenerative braking was good to see on an environmental basis. Suitable methods, materials, tools and equipment (hardware and software) were deployed to produce the solution. The mechanical aspects were primarily sub-contracted and problems with the quality of the aspect were explained and solutions suggested. High quality result for most aspects of the project with a few issues of hardware build that could be improved. Test equipment was mainly software based. Results were clearly presented as dynamic graphs and spreadsheet tables. Good evidence of planning comparing initial and final plan within budget. (20/25) **20**

5. TRANSFERABLE SKILLS

 Mostly very good, clear images and diagrams. However, some slides contained too many words. Confident, clear and professional delivery style. (8.5/10) **8.5**