APPENDIX -I

20-211-0611 Safety Instrumented Systems

Total hrs: 48

L	T	P	C
2	1	0	2

Course outcomes:

After completion of this course, the student will be able to:

CO1: Explain the importance of safety in process industries (Understand)

CO2: Explain the relevant standards governing functional safety in process industries (Understand)

CO3: Explain the importance of the lifecycle approach in achieving functional safety (Understand)

CO4: Associate the relation between risk reduction and SIL levels (Understand)

CO5: Understand the importance of product certification for SIL level (Understand)

CO6: Explain the different SIS PLCs used in the process industry (Understand)

Module I

Safety - Industry practises, Key Concepts - International standards and guidelines on Safety Instrumented Systems (SIS) design and follow-up in Oil & Gas industry, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-related Systems - IEC 61508. Instrumented protective function (IPF) – Hazard- Trip-Alarm- SIS standards in Oil & gas industry

Module II

Safety Instrumented Functions (SIF) Vs SIS – Risk assessment- IEC 61508 & IEC 61511, hazard and operability study (HAZOP), Shutdown levels, Safety integrity level (SIL) classification, Probability of Failure on Demand (PFD), Safe Failure Fraction (SFF), Dangerous failure and Safe Failures- Safety integrity level (SIL), Fault Tolerance, Equipment Under Control (EUC) control system & SIS, Safety Life cycle

Module III

SIS Architecture, SIS Manufacture qualification, Safety and Reliability, System Model, Common Cause Failure (CCF), Diagnostic testing and reporting, Spurious activation, and Factors influencing spurious activation.

Module IV

Logic Solver- Evolution of Logic solver- SIS PLC, Functional safety life cycle approach. The need for Product Certification and Engineer certifications.

References:

1. IEC61508-1, "Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirements," IEC 1998

2. IEC61511-1, "Functional safety - Safety instrumented systems for the process industry sector, Part 1: Framework, definitions, system, hardware and software requirements," International Electrotechnical Commission (IEC) 2003.

3. D. J. Smith and K. G. L. Simpson, Functional safety - A straightforward guide to applying the IEC 61508 and related standards, Second edition ed: Elsevier, 2005.

4. SINTEF, "Reliability Prediction Methods for Safety Instrumented Systems - PDS Method Handbook, 2006 Edition," SINTEF 2006

5. S. Brown, "Overview of IEC 61508. Design of electrical/electronic/programmable electronic safety-related systems," Computing and Control Engineering Journal, vol. 11, 2000

6. P. Hokstad, "Estimation of Common cause factors from systems with different channels," IEEE Transactions on Reliability, vol. 55, 2006.

20-211-0612 Electronic Product Design Through Experiential Learning

Total hrs: 48

Course outcomes:

After completion of this course, the student will be able to:

CO1: Understand the electronic product development process (Understand).

CO2: Describe the principle and instrumentation of a grating-based spectrometer and requirement capture for designing a UV-VIS spectrometer (Understand, Analyze).

CO3: Design and development of hardware for a grating spectrometer (Apply).

CO4: Design and development of the embedded system for a grating spectrometer (Apply).

CO5: Realise and validate modules,, interfaces and the final product (Create).

Module I

Industrial Design of Electronic Products

Product Development Process: Product definition and intended use, Product requirements and specifications, Concept development, Product Architecture, and Project & Product Management. Industrial Design: Aesthetic, Ergonomic, Manufacturing, Cost, Thermal, and EMI/EMC. Quality and Testing: DFMA, DFT, Prototyping, Patents & IPR, Product Development Economics, Quality

Concepts, QFD, ISO9000, Reliability, DFMEA, Standards, certifications, regulatory compliance testing and Documentation

Module II

Design Challenge: Spectrometer

Spectroscopical methods of analysis: Basics of Spectral methods of analysis, various ranges of electromagnetic radiation. Interaction of E.M. radiation with matter, absorbance and transmittance relationship.

Problem definition & requirement specification: Wavelength, frequency, or energy range, resolution, temporal response, measurement time, the field of view, spatial resolution, accuracy & precision, SNR & noise characteristics, signal and controls for configuration. Dynamic range, size, power, and connectivity. Environmental constraints such as temperature and humidity operating range. UV-Visible Spectroscopy- Beer-Lambert's Law-its limitations. Concept of emission, absorption and scattering techniques. Instrumentation for UV-Visible Spectroscopy.

Module III

Design of a UV-VIS grating spectrometer

Diode array spectrometer working principle, Czerny-Turner and transmission-based design, design flow chart, governing equations for grating and optics

Design: geometry selection, grating equation and selection, calculation of diffraction angle, detector selection, the focal length of the focus lens, magnification, focal length of collimation lens, calculation of input slit width

Evaluation of design: Spectral resolution and diffraction limits.

Module IV

Product Development

Electronic design & development: Signal chain and data acquisition, power supply design and selection, component and footprints, PCB design, layout/gerber, procurement, fabrication, board bring up and validation.

Embedded System design and development: Introduction to STM32 Cortex M3 hardware, Introduction to CMSIS, JTAG/SWIM-based debugging using ST-LINK/V2, Introduction to STM32 Cube MX graphical configuration and generating the code in KEIL / TrueStudio.

C Programming: Understanding timing charts of CCD/CMOS line array sensors and interfacing line array sensor to the microcontroller; Data acquisition and signal conditioning; Post processing; interfacing to host controller.

Host-side software development: PC-side software development to control and acquire data from the spectrometer.

UX and mechanical design: Spectrometer enclosure design and fabrication, 3D printing.

Product Realisation & Validation

Done as a group project where the students will be realising a UV-VIS spectrometer based on the design principles covered in previous sessions. This should involve defining requirements and translating them into product specifications and realization of the product through electronic, mechanical and industrial design within the cost and time constraints.

References:

1. Crocombe, Richard A., Pauline E. Leary, and Brooke W. Kammrath, eds. Portable Spectroscopy and Spectrometry, Applications. John Wiley & Sons, 2021. ISBN:9781119636489, DOI:10.1002/9781119636489.
2. Loewen, Erwin G., and Evgeny Popov. Diffraction gratings and applications. CRC Press, 2018. ISBN 9781315214849, DOI: 10.1201/9781315214849.
3. Roduner E, Krüger T, Forbes P, Kress K. Optical Spectroscopy: Fundamentals and Advanced Applications, World Scientific Publishing Europe Ltd, 2019.
4. Scheeline, Alexander. "How to design a spectrometer." Applied Spectroscopy, Vol.71, Issue.10, 2017, pp. 2237-2252. DOI: 10.1177/0003702817720468.
5. Spectrometer design guide: https://ibsen.com/resources/spectrometer-resources/spectrometer-design-guide/